PRACTICAL MANUAL FOR ELECTRICAL ENGINEERING SCIENCE II

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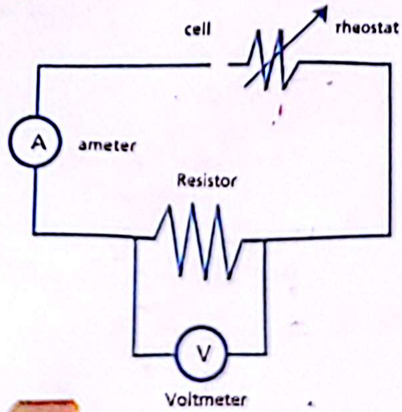

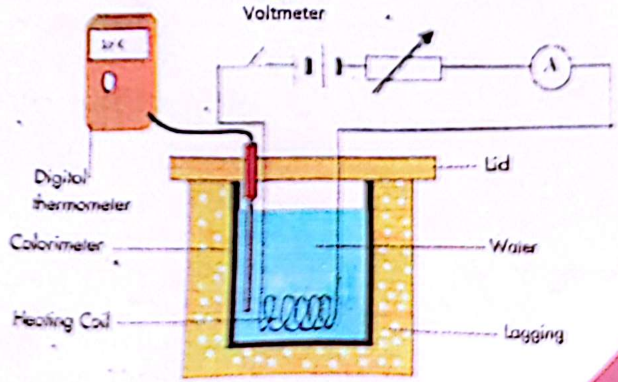

BY

ENGR ANIGBOGU G. O.

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FOR

ELECTRICAL ENGINEERING SCIENCE II

ENGR ANIGBOGU G. O.

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2015.

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EXPERIMENT 1

Hysterisis loop for a ferromagnetic material (B-H curve)

AIM: To study the magnetization (M) of a ferromagnetic material in the presence of a magnetic field B and to plot the hysterisis (B-H) curve .

Apparatus:
Two solenoid coils, S and C, ferromagnetic specimen rod, reversible key (R), ammeter, magnetometer, battery, solenoid, rheostat and transformer for demagnetizing set up.

Basic Methodology:
A ferromagnetic rod is magnetized by placing it in the magnetic field of a solenoid. The magnetized rod causes a deflection (θ) in a magnetometer .The deflection θn is recorded as the current in the solenoid (I) is varied over a range of positive and negative values

Theory: A ferromagnetic material whose atoms behave like magnetic dipoles produced by the spins of unpaired electrons. Domains form in the interior of the material with in which the dipoles align in a given direction but the domains themselves randomly oriented (see the figure below)

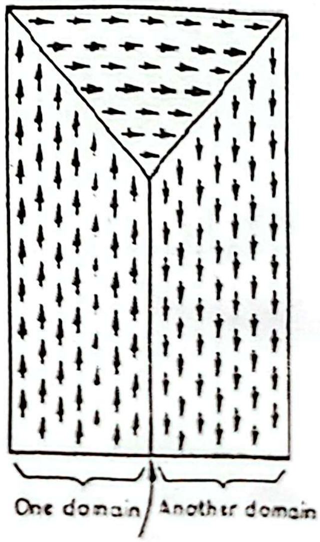


Fig 1: Ferromagnetic material

In the presence of an externai magnetic field the different domain moments tend to align producing a net magnetization in the direction of the magnetic field

The variation of the magnetization M as the magnetic field B is varied gives rise to a characteristic curve called the hysterisis loop. Figure 2 shows a typical curve obtained. (The axes are taken to be Tan θ & I as is to be done in the experiment). As the magnetic field is increased the magnetization of the sample increases as more and more domains align along the direction of the magnetic field. With further increase in B, the magnetization M saturates to a maximum value (point b). If the current I (field B) is decreased the magnetization M decreases.

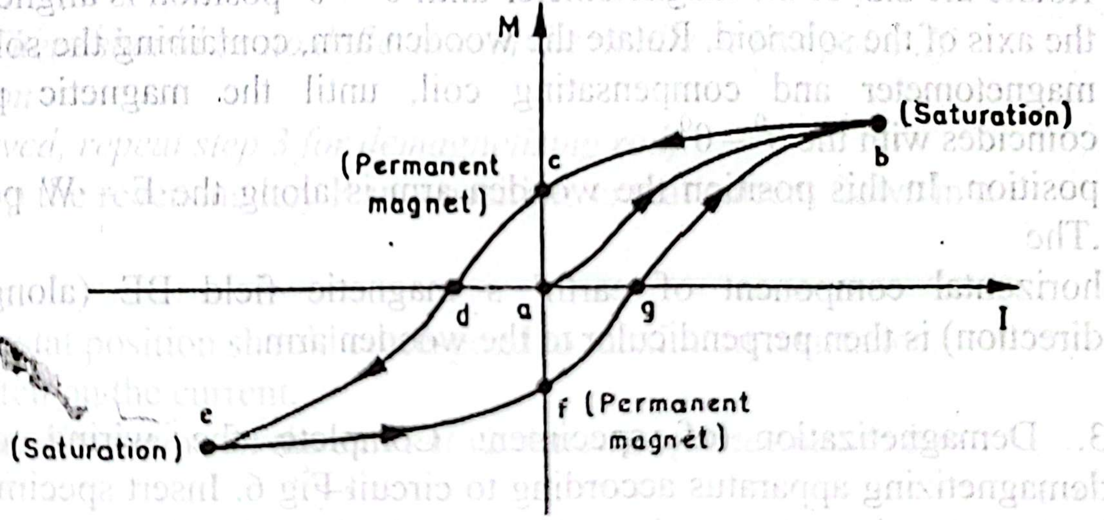
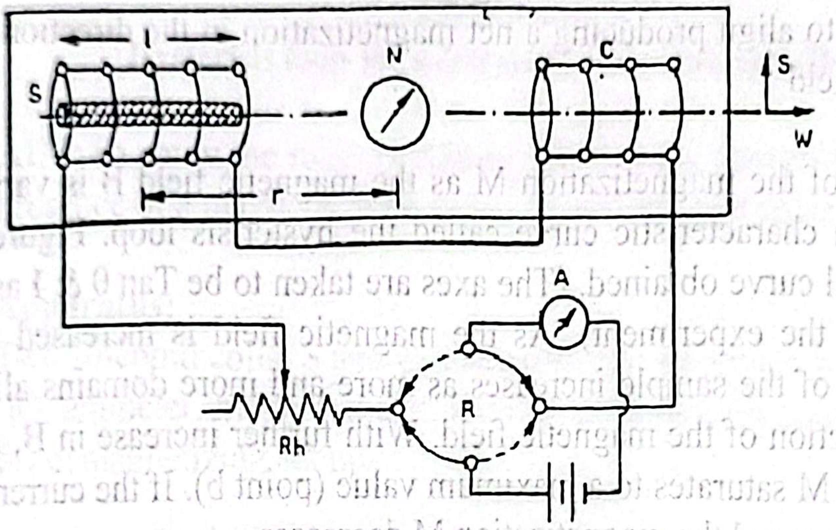


Fig 2: B-H curve

When the current is made zero (point c) the magnetization M however does not fall to zero. At this point the material has a residual magnetization and behaves like a permanent magnet. To make the magnetization zero (point d) requires a non-zero current in the reverse direction. As I is increased in the reverse direction, M saturates to a maximum negative value (point e). Further increase in the current brings the magnetization to zero (point g) and eventually to saturation (point b).

Set-up and procedure:

1. Complete the wiring of the apparatus according to the circuit diagram,



2. Alignment of apparatus:
Rotate the dial of the magnetometer until $0^0 - 0^0$ position is aligned with the axis of the solenoid. Rotate the wooden arm, containing the solenoid, magnetometer and compensating coil, until the magnetic pointer coincides with the $0^0 - 0^0$
position. In this position the wooden arm is along the E – W position .The
horizontal component of earth' s magnetic field BE (along S-N direction) is then perpendicular to the wooden arm.

3. Demagnetization of specimen: Complete the wiring of the demagnetizing apparatus according to circuit Fig 6. Insert specimen rod in the solenoid and vary the AC current in the solenoid using rheostat. This procedure should take 2-5 minutes.

4. Positioning of the Compensating Coil:
Pass current (say 1A) through the coils S & C. Vary the position of C along the wooden arm until the deflection of the needle is zero The magnetic field of solenoid S is then nullified (at the position of magnetometer) by the magnetic field of C .

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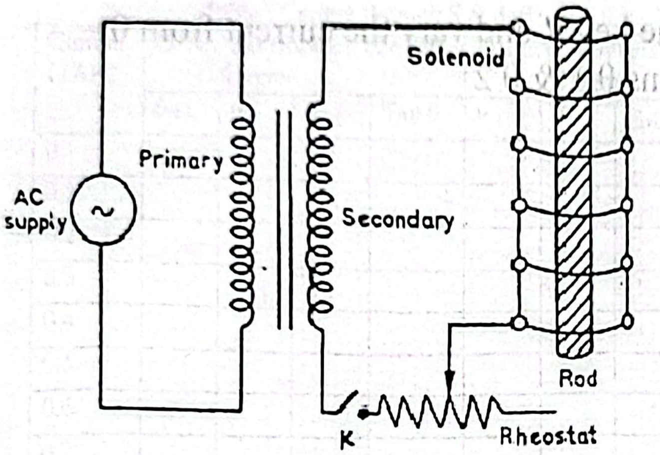

5. Begin Measurement:
i). To begin with, the current in the solenoid should be switched off.
ii). Insert specimen rod so that it' s leading tip is at the edge of the solenoid.
(Note: There should be no deflection of the needle at this point .If deflection is observed, repeat step 3 for demagnetizing rod).
iii). Keep the reversing key R in a position so that current flows in a given direction.
The rheostat position should correspond to maximum resistance.
iv). Switch on the current.
(Caution: From now on the current variation sequence has to be followed strictly Any change or back tracking of measurement will lead to incorrect results).
v). Vary the current using the rheostat from 0A – 1.5A and back 1.5A – 0A insteps of 0.1A and note the deflections θ1 & θ 2 for each setting of current.
(Caution: To get strictly zero current you will have to switch off the battery)
vi). Reverse the position of the reversible key R and vary the current in the reverse direction 0A – 1.5A ,and back 1.5A – 0A .Note the deflections θ1 &

θ2

vii). Reverse the position of the key R and vary the current from 0 – 1.5A. Again note the deflections θ 1 & θ 2

Exercise

Complete the table below

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Table : Current through S & deflection θ

Current I (A)	Deflection (forward current) Degree				Deflection (reverse current) Degree				Deflection (forward current)			
	θ_1	θ_2	θ_{avg}	Tan θ	θ_1	θ_2	θ_{avg}	Tan θ	θ_1	θ_2	θ_{avg}	Tan θ
0												
0.1												
0.2												
0.3												
0.4												
0.5												
0.6												
0.7												
0.8												
0.9												
1.0												
1.1												
1.2												
1.3												
1.4												
1.5												
1.4												
1.3.												
1.2												
1.1												
1.0												
0.9												
0.8												
0.7												
0.6												
0.5												
0.4												
0.3												
0.2												
0.1												
0												

2 plot a graph of Tanθ vs. I.

3 Define paramagnetic, diamagnetic & ferromagnetic substances. Give one example of each.

4 Draw a small figure showing how the hysterisis curve would develop over many cycles of the current.

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EXPERIMENT 2
Resonance in LCR circuit

Aim: To study resonance effect in series and parallel LCR circuit and quality factor. *This experiments also enables study of forced damped oscillation.*

Apparatus: A signal generator, inductor, capacitor, ammeter, resistors, AC milli voltmeter.

Basic methodology:
In the series LCR circuit, an inductor (L), capacitor (C) and resistance(R) are connected in series with a variable frequency sinusoidal emf source and the voltage across the resistance is measured. As the frequency is varied, the current in the circuit (and hence the voltage across R) becomes maximum at the resonance frequency. In the parallel LCR circuit there is a minimum of the current at the resonance frequency.

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

Power Resonance:
The power dissipated at the resistor is P = I V = I2R = V2R

The average power dissipated over one cycle is

$$\bar{p} = \frac{I_0^2 R}{2}$$

The graph of P against frequency shows that the maximum power Pm value occurs at the resonating frequency

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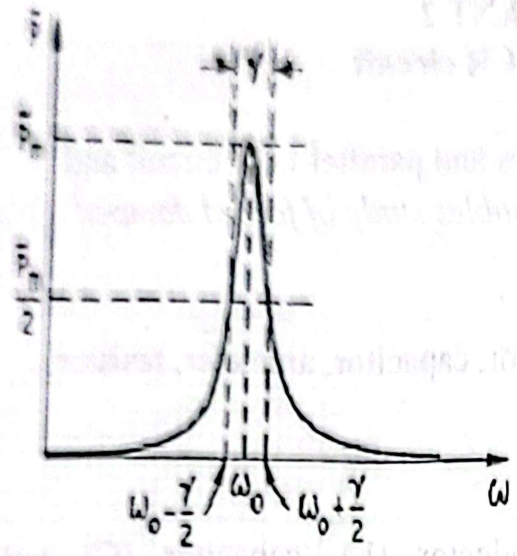

It can be shown that to a good approximation, which the power falls to half of the maximum value

$\overline{P_m}/2$ at $f = f_r \pm \frac{\gamma}{2}$

Here γ is related to damping in the electrical circuit and is given by $\gamma =$ R/L. The width or range of f over which the value of p falls to half the maximum at the resonance is called the Full Width Half Maximum (FWHM). The FHWM is a characteristic of the power resonance curve and is related to the amount of damping in the system. Clearly FWHM = γ = R/L. One also defines the quality factor Q as

$$Q = \frac{f_r}{\gamma} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

which is also measure damping. Large Q (small R) implies small damping while small Q (large R) implies large damping. Clearly we have FWHM = □ = R/L. Thus, the quality factor Q can be determined from the FWHM of the power resonance graph.

Procedure:

1. The series and parallel LCR circuits are to be connected as shown in fig 1 & fig 2.

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2. Set the inductance of the variable inductance value and the capacitances the variable capacitor to low values (L ~ 0.01H , C ~ 0.1 μ F) so that the resonant frequency is of order of a few kHz .
3. Choose the scale of the AC milli voltmeter so that the expected resonance occurs at approximately the middle of the scale.
4. Vary the frequency of the oscillator and record the voltage across the resistor.
5. Repeat (for both series and parallel LCR circuits) fir three values of the resistor (say R = 100, 200 & 300 Ω).

Connection Diagram

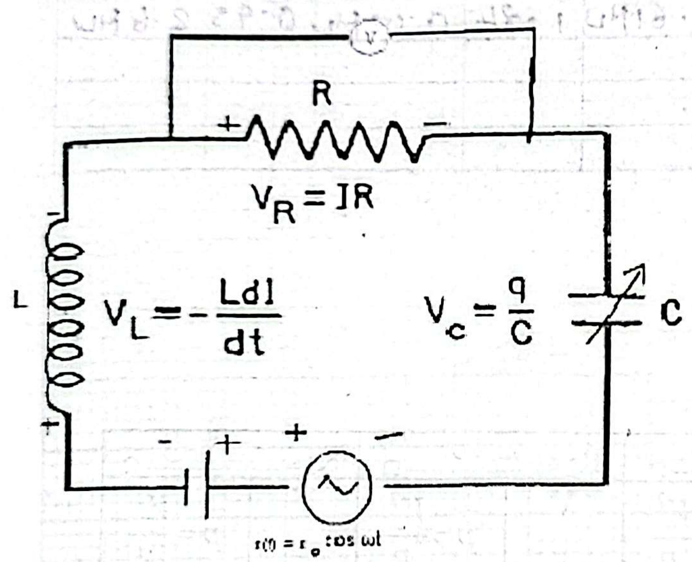

Fig1 : circuit set up for series connection

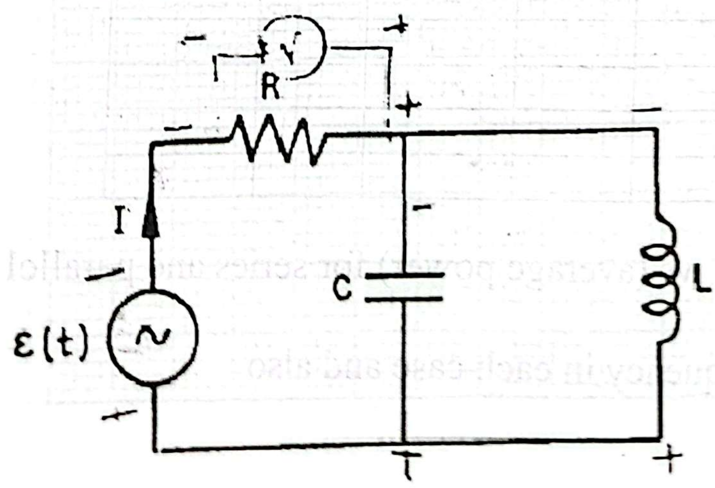

Fig2 : circuit set up for parallel connection

Exercise

1. Complete the table below

For Series LCR Circuit.

L = ________________ mH

C = ________________ μF

S.No.	Frequency (υ) kHz	R_1 = 100 Ω		R_2 = 220 Ω		R_3 = 330 Ω	
		V	$\bar{p}=\frac{V^2}{R}$	V	$\bar{p}=\frac{V^2}{R}$	V	$\bar{p}=\frac{V^2}{R}$
1	19 kHz	0.009	0.81 μW	0.09	3.6 μW	0.05	7.6 μW
2	17 kHz	0.126	0.15 μW	1.09	6.4 μW	0.43	5.6 μW
3	13 kHz	0.248	0.61 μW	1.84	0.02 μW	0.93	2.6 μW
4							
5							
6							

C = ________________ μF

For Parallel LCR Circuit.

L = ________________ mH

C = ________________ μF

S.No.	Frequency (υ) kHz	R_1 = 100 Ω		R_2 = 220 Ω		R_3 = 330 Ω	
		V	$\bar{p}=\frac{V^2}{R}$	V	$\bar{p}=\frac{V^2}{R}$	V	$\bar{p}=\frac{V^2}{R}$
1	19	0.01	1.	0.18	3.24 μW	0.19	1.093 μW
2	17	0.19	0.036	0.12	6.54 μW	0.03	2.72 μW
3	13	0.02	4.	0.38	6.56 μW	0.05	7.57 μW
4							
5							
6							

2 Plot the graph of frequency vs (average power) for series and parallel cases.

3 Determine the resonant frequency in each case and also

4 Determine the Q- factor.

$$Q=\frac{f_r}{\gamma}=\frac{1}{R}\sqrt{\frac{L}{C}}$$

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EXPERIMENT 3

Self Inductance and resistance of a coil

Aim: To determine the self inductance and resistance of a coil with air core and iron core.

Apparatus: inductance, Resistance, power source

Theory:

Let us consider an R-L circuit connected to an ac supply as shown in *Fig 1*.

Practically it is not possible to have an ideal inductor at room temperature. The present inductor coil has a self inductance of 'L' and resistance 'r'. Let V 1 be the voltage drop across the coil which is the combination of voltage drop due to inductance 'L' and resistance 'r'. Let VL and Vr be the voltage drop due to the inductive and resistive parts of the coil. From *Fig.2*

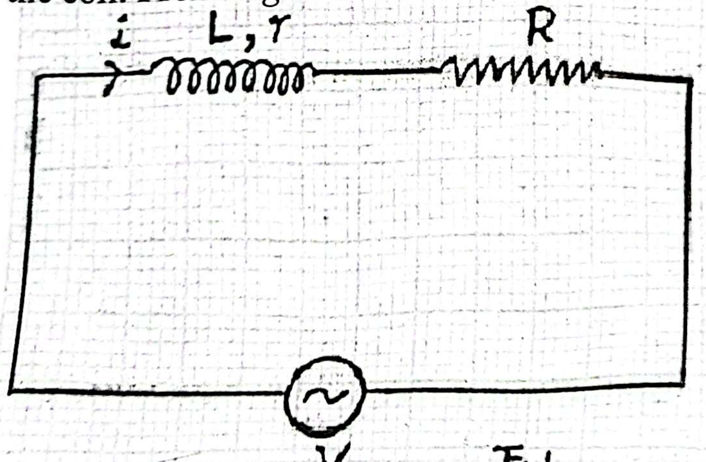

Fig 1

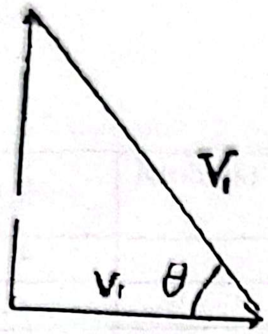

Fig 2

$$V_1 = \sqrt{(V_L^2 + V_r^2)} \text{ ---------------------------------(1)}$$

Let V2 be the voltage drop across the resistor 'R' and 'V' be the total voltage drop across the R-L Circuit. The complete phase diagram is shown in *Fig 3*.

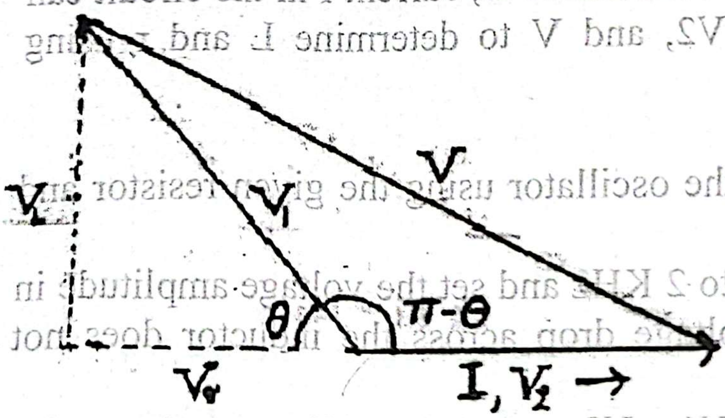

Fig 3

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From Fig.3.

$$V^2 = V_1^2 + V_2^2 - 2V_1V_2Cos(\pi-\theta)$$

Or

$$V^2 = V_1^2 + V_2^2 + 2V_1V_2Cos(\theta) \ldots(2)$$

$V_r = V_1 \, Cos\, \theta$ -------------------(3)

$V_L = V_1 \, Sin\, \theta$------------------- (4)

Also $V_L = I.L.\omega$ ------------------(5)

and $V_r = I\, r$------------------ (6)

By measuring the voltage V across resistor R, current I in the circuit can be determined. Measure V1, V2, and V to determine L and r using equations (2) to (6).

Procedure:

1. Connect the R-L circuit to the oscillator using the given resistor and inductor coil (Fig. 1).
2. Set the oscillator frequency to 2 KHz and set the voltage amplitude in the oscillator such that the voltage drop across the inductor does not exceed voltage limit.
3. Measure the voltage drops V1 , V2 and V for different values of R (Table1).
4. Repeat the experiment by inserting an iron rod into the inductor coil.

Exercise

1. Complete the table
2. From eq (2) to eq (6) calculate the inductance L and resistance r of the coil for air core and iron core

3. Plot them as a function of current in the circuit.

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Table1

Sl No.	R(ohms)	V(volts)	V_1(volts)	V_2(volts)

Table 2

Sl No	R(ohms)	I(amps)	L(mH)	R(ohm)

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EXPERIMENT 4
ELECTRIC POWER AND HEAT

Aim : To demonstrate that electric power can produce heat

Theory: a conductor becomes hot after sometime when it carries current. This shows that current has a heating effect. That is passage of current is always accompanied by generation of heat. Thus electrical work or energy can be converted to heat.

Joule's law of electric heating states that heat produced by an electric current I, flowing through a resistor R for a fixed time, T is given by I^2Rt.
If V is the voltage across the resistor, the electrical power P is given by:

$P = I V$ or $P = I^2R$ or $P = V^2/R$

Procedure:
Connect the circuit as shown below

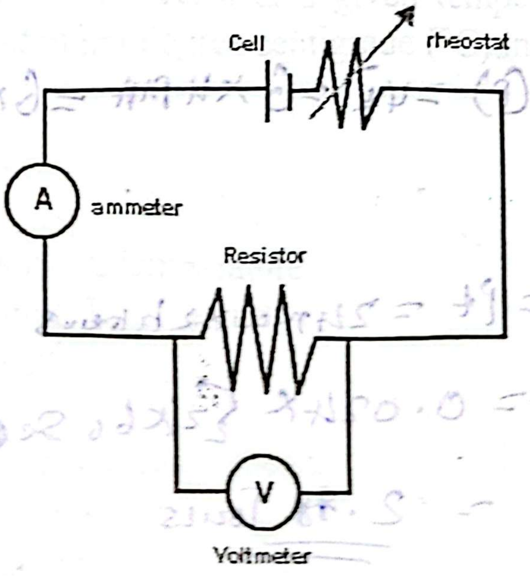

Fig 1. Experimental set up

Touch the resistance wire while the key is open. Close the key for sometime. Touch the resistance wire again. What did you notice?

Take the reading of the voltmeter and ammeter at a time,t after the key is closed. Note tha value of time, t . calculate the resistance, R of the resistor at time t.

Calculate the electric power and also the amount of heat generated in he wire at time, t

Exercise

1. A current of 4mA flows in a circuit of 1.5KΩ resistor. Determine:
   a. The voltage across the circuit
   b. The power dissipated
   c. The total heat energy if the current flows for 2 hours.

Solution

y = 4mA, R = 1.5KΩ

(a) from V = IR = 4mA × 1.5KΩ = 6V

(b) Power (P) = VI = 6 × 4mA = 6×4×10⁻³
= 0.024w
= 0.024 w

(c) Heat = Pt = 24mw×2hours = 2.4mw
= 0.024 × (2×60 seconds)
= 2.88 Joules

EXPERIMENT 5
TEMPERATURE AND RESISTANCE

Aim: To investigate the variation of the resistance of a metal wire with temperature and to determine the temperature coefficient of resistance(α) of a metal wire.

Theory: Increase in temperature increases the resistance of a pure metal (eg copper wire). The resistance, Ro of a metal at a given temperature θ is given by

$$Ro = Ro + \alpha o Ro\theta$$

Where Ro= resistance at 0°C temperature and αo= temperature coefficient of resistance of a given conductor at 0°C

In metal, the graph at resistance against temperature is a straight line. The slope of the graph can be used to calculate the temperature coefficient of resistance. The intercept on the graph gives the resistance at initial temperature.

Temperature coefficient of resistance, α at a given temperature is the change in resistance from ohm per degree centigrade (°C) in temperature from the given temperature

Mathematically , $\frac{Ro-Ri}{Ri \, x \, \Delta\theta}$

Where Ro= Resistance at a given temperature

Ri= resistance at initial Temperature

$\Delta R = Ro - Ri = \alpha Ri \Delta\theta$

This implies that increase in resistance depends:

1. Directly on its initial resistance
2. Directly on the rise in temperature
3. On the nature of the material of the conductor.

If a conductor chsnges its resistance Ro at 0°C to a resistance Ro at θ°C, the temperature coefficient αo at θ° is given by

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$$\alpha_0 = \frac{\alpha_{oi}}{1+\alpha_o\theta}$$

Apparatus: Coiled insulated copper wire, ohmmeter, glass container, liquid (water or paraffin), thermometer, heat arrangement.

Procedure: immerse the copper coil in the liquid contained in a glass container. With the aid of a thermometer, measure the temperature θ of the free ends of the wire to an ohmmeter and measure the resistance (R) of the insulated copper wire at the measured temperature.
Note the thermometer and corresponding ohmmeter reading.
Apply heat to the glass container so as to increase the temperature of the metal wire.

As heat is being applied, take the various reading of the thermometer (θ) and the corresponding reading of the ohmmeter (R). obtain at least seven readings.

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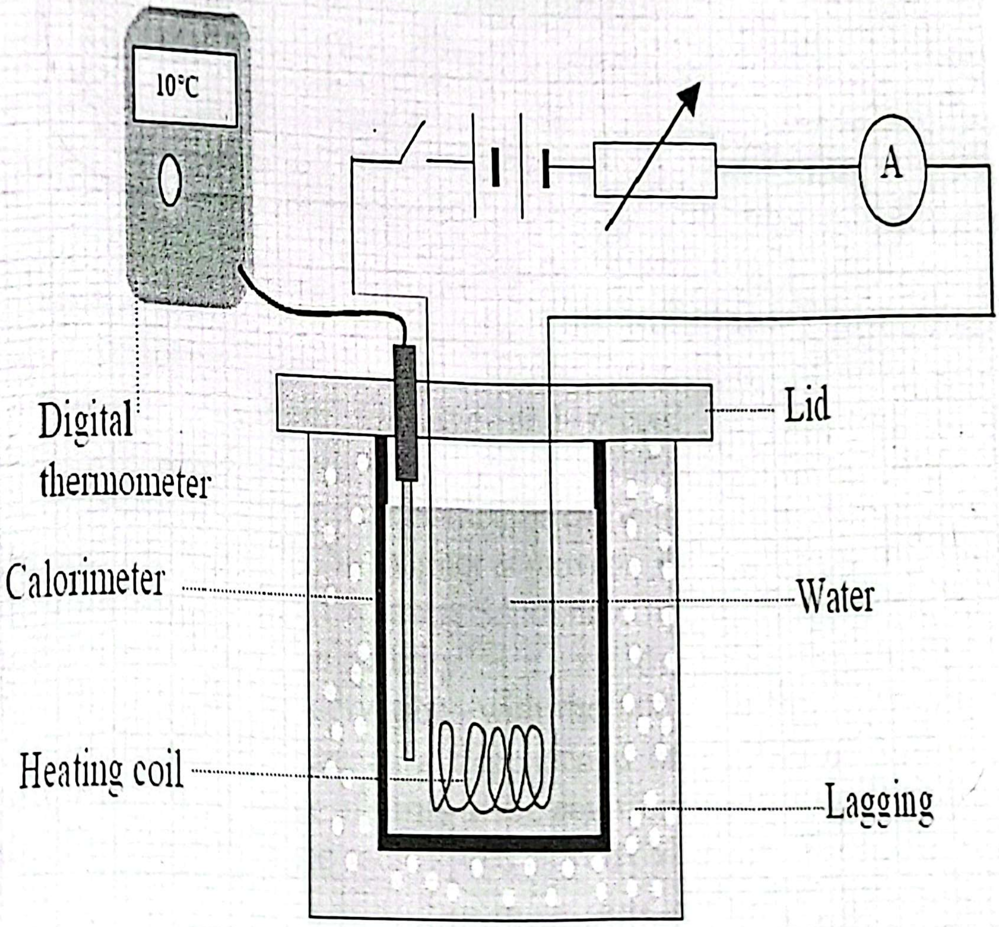

Exercise:

1. Plot a graph of resistance (R) against the corresponding temperature (θ). Measure the slope and the intercept of the graph. Hence calculate the value of αo. Discuss the nature of the graph.

From the graph, what is the resistance value at 0°C and 100°C. use these values of resistance to calculate for αo and compare this calculated value, with the result of αo obtained using graph.

2. Compute the value of αo at 40°C, 60°C and 80°C

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3.What is the trend of α with temperature, θ?

4. At what temperature is α expected to be maximum?

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EXPERIMENT 6
ELECTROMAGNETIC INDUCTION: FARADAY'S AND LENZ'S LAWS

Aim: The effects of Faraday's Law and Lenz's Law will be observed in this experiment. It is important that all results be interpreted in terms of the predictions of these laws.

Theory

Faraday's Law: If a circuit is placed in a region of varying magnetic flux, an emf equal to the time rate of change of the magnetic flux through the circuit is induced in the circuit

$$emf = -\frac{d\Phi}{dt}$$

In this experiment, the varying magnetic flux is produced by a varying magnetic field, so

$$emf \propto -\frac{dB}{dt}$$

Lenz's Law: For any closed circuit in a region of varying magnetic flux, the direction of the induced current which results from the induced emf is such that it produces a magnetic field that opposes the change in the magnetic flux.

A. PERMANENT MAGNET

Connect the 300 turn coil to the galvanometer as shown below. Be sure that the coil B terminal is connected to the galvanometer red terminal. Set the rheostat to full resistance.

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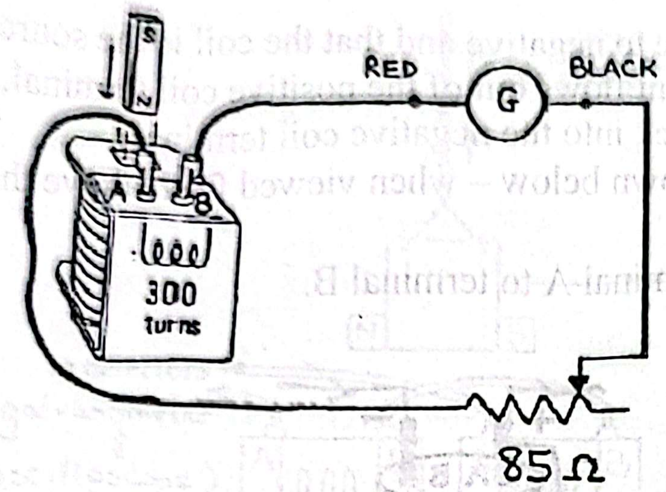

Take the bar magnet and rapidly push the North end into the square opening in the coil. Observe and record the polarity (+ or –) of the galvanometer deflection. Observe and record the polarity of the deflection as the bar magnet is rapidly withdrawn. Also observe and record whether there is a dependence of the magnitude of the deflection on the speed with which the magnet is moved.

Reverse the bar magnet (i.e. insert South pole first) and repeat the above observations of deflection polarity.

Repeat all the above observations with the 600 turn coil. Also observe and record whether there is a dependence of the magnitude of the deflection on the number of turns in the coil (for this you will have to try to move the magnet at the same speed as you did with the 300 turn coil).

Record your observations in a manner similar to the following:

	Polarity of Galvanometer Deflection			
Coil	North in	North out	South in	South out
300 turn				
600 turn				

Dependence on speed of magnet motion:

Dependence on # of coil turns:

To aid in analyzing the response of the galvanometer, note that the polarity of the galvanometer deflection indicates the polarity of the terminal connected to the red galvanometer post. Also, remember th

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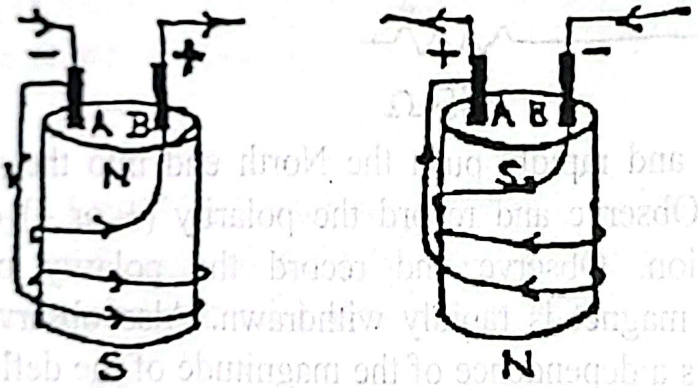
current flows from positive to negative and that the coil is the source of emf in the circuit (so current flows out of the positive coil terminal, through the circuit, and back into the negative coil terminal).
The coils are wound as shown below – when viewed from above the winding is
counterclockwise from terminal A to terminal B.

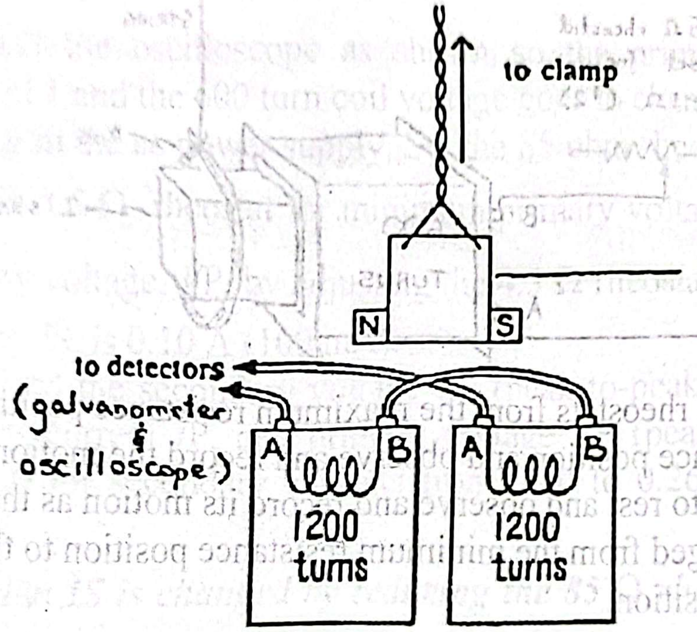


When terminal B is positive, indicating that current is flowing out of B, the induced magnetic field has a North pole at the top of the coil. When terminal B is negative, indicating that current is flowing into B, the induced magnetic field has a South pole at the top of the coil.
Based on the previous paragraph, interpret your deflection polarity observations in terms of the predictions of Lenz's Law. Is there agreement? Discuss.

What does Faraday's Law predict for the dependencies of deflection magnitude on magnet speed and number of coil turns? Do your observations agree with these predictions?

B. GENERATION OF ALTERNATING VOLTAGES

Connect two 1200 turn coils in series, as shown below, so that the emf's generated in the windings add constructively. Suspend the bar magnet in a holder above the coils.



Suspend the magnet directly over and about 1 cm above the coils. Wind the string and release the magnet so that it spins in a horizontal plane above the coils. Observe and record the response of the galvanometer and oscilloscope. Note any dependence of magnitude of response on speed of magnet rotation.

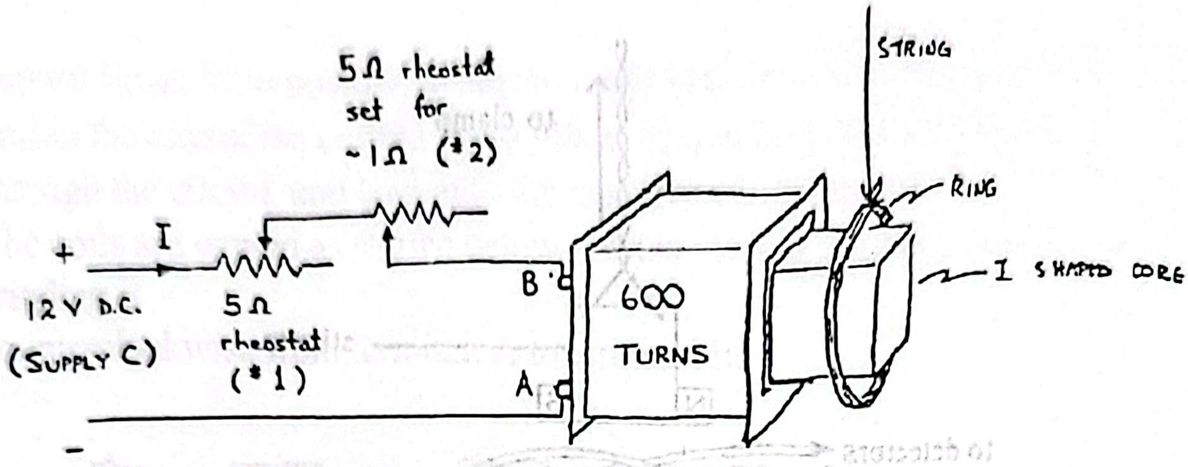
Adjust the magnet so that it is much higher above the coils. Again spin the magnet and note whether there is any dependence of instrument response on magnet-coil separation.

Place the two coils on the C core from the mounting frame and repeat the observations of galvanometer and oscilloscope response when the magnet is spun above the coils.

Compare all of your observations with the predictions of Faraday's Law of Induction.

C. LENZ'S LAW

Use a paper wedge to hold the I core in the 600 turn coil as shown. Plac the coil on its side and suspend the aluminum ring so that the I co passes through the ring. Connect the circuit as shown.

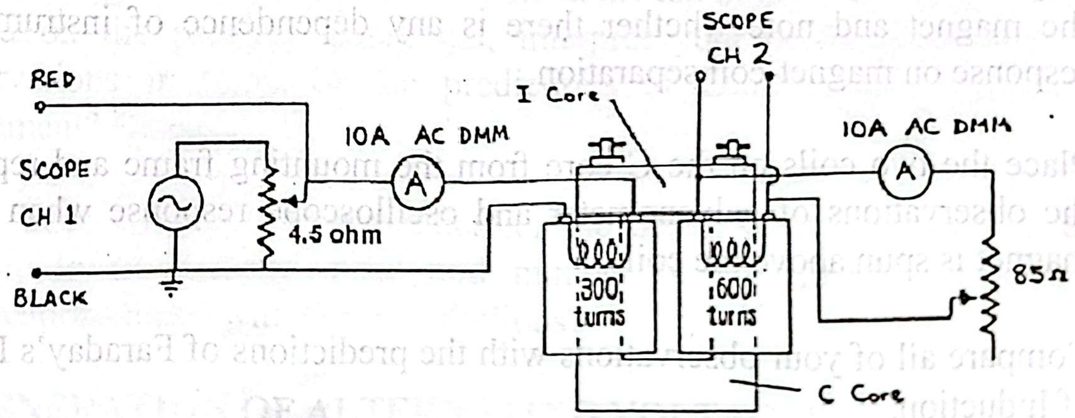


Rapidly slide one of the rheostats from the maximum resistance position to the minimum resistance position and observe and record the motion of the ring. Bring the ring to rest and observe and record its motion as the rheostat is rapidly changed from the minimum resistance position to the maximum resistance position.

Explain the ring's motion (toward or away from the coil) in terms of Lenz's Law.

D. THE TRANSFORMER AND MAGNETIC CIRCUITS

Procedure



Mount the 300 turn primary and 600 turn secondary coils on the C core in the mounting frame and complete the magnetic circuit with the I core. Be sure that the I core is clamped down firmly with the mounting frame and that its laminations align with those of the C core. Connect the circuit as shown. The variable ac supply (set for 10 V AC), 4.5Ω rheostat, AC ammeter, and 300 turn coil form the primary circuit and the 600 turn coil, AC ammeter, and 85V rheostat form the secondary circuit.

Connect the oscilloscope as shown so the primary voltage goes to channel 1 and the 600 turn coil voltage goes to channel 2.

1. Plug in the ac power supply. Set the 85 ohm rheostat to full resistance and the 4.5 Ω rheostat for minimum primary voltage. Slowly adjust the primary voltage, *VP*, by adjusting the 4.5 Ω rheostat, until the secondary current, *IS*, is 0.10 A (100 mA).

2. Record the secondary voltage *VS* (peak-to-peak Channel 2 voltage), primary current *IP*, and primary voltage *VP* (peak-to-peak Channel 1 voltage) for secondary currents from 0.10 to 0.26 A in increments of 0.04 A.

Note that IS is changed by reducing the 85 Ω rheostat resistance. Do Not adjust the 4.5 Ω rheostat once it has been set as described in step 1.

3. Disconnect a wire in the secondary circuit (i.e. disconnect one of the leads at the 85 Ω rheostat), leaving the secondary open-circuit (*IS* = 0, *RS* = ∞). Record the primary and secondary voltages, *VP* and *VS*.

I_S (± _A)	Secondary Voltage (V) Displ. (± _cm)	V/cm	V_S	I_P (± _A)	Primary Voltage (V) Displ. (± _cm)	V/cm	V_P	V_S/V_P	$V_S I_S$ (W)	$V_P I_P$ (W)	% Power Loss
0.10											
0.14											
0.18											
0.22											
0.26											
0.00											

Now the effect of introducing nonmagnetic 'air' gaps in the magnetic circuit will be examined under the condition of constant secondary current. Set the 85 Ω rheostat to full resistance and the 4.5 Ω rheostat to zero primary voltage.

4. Loosen the mounting frame clamps and place a paper towel folded into 8 paper thicknesses between the C core and I core. Clamp the I core down firmly and increase the primary voltage by adjusting the 4.5 Ω

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rheostat until the secondary current, I_S, is 0.10 A. Record V_S, I_P, and V_P.

5. Repeat step 4. for 16 and 32 paper towel thicknesses.

BE SURE TO REDUCE THE PRIMARY VOLTAGE TO 0 BEFORE CHANGING PAPER THICKNESSES.

Paper Thickness	Secondary Voltage (V) Displ. (± _cm)	V/cm	V_S	I_P (± _A)	Primary Voltage (V) Displ. (± _cm)	V/cm	V_P	$V_S I_S$ (W)	$V_P I_P$ (W)	% Power Loss
0										
8										
16										
32										

Theory

If the transformer were ideal, i.e. no leakage losses or core heating, no eddy losses in the magnetic core, and no Joule heating in the windings, then the power $V_P I_P$ delivered to the primary would equal the power $V_S I_S$ transferred to the secondary.

$V_P I_P = V_S I_S$ (1)

But the flux in such a case is completely contained in the magnetic circuit so the flux through the secondary and the flux through the primary are equal. Therefore, since the induced emf is

$$V_S = N_S \frac{d\Phi}{dt} \quad \text{in the secondary}$$

$$V_P = N_P \frac{d\Phi}{dt} \quad \text{in the primary.}$$

$$\frac{V_P}{V_S} = \frac{N_P}{N_S} = a \qquad (2)$$

where a is called the turns ratio. From (1) and (2),

$$\frac{V_P}{V_S} = \frac{I_S}{I_P} = \frac{N_P}{N_S} = a$$

Analysis

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Calculate and tabulate values of primary power, V_pI_p, and secondary power, V_sI_s, for the measurements made in part 2. Does the power relation (1) hold for your results? i.e. Does $V_pI_p = V_sI_s$ within experimental error?
Calculate the percentage power loss

$$\%\text{ Power Loss } = \frac{V_pI_p - V_sI_s}{V_pI_p} \times 100\% = \left(1 - \frac{V_sI_s}{V_pI_p}\right) \times 100\%$$

Plot a graph of % Power Loss versus secondary current for the values measured in part 2. Where do the losses occur?
Calculate, tabulate, and plot the voltage ratio V_s/V_p versus secondary current for the values measured in parts 2. and 3.
Calculate and tabulate the primary power, V_pI_p, secondary power, V_sI_s and % Power Loss for the values measured in parts 4. and 5. Plot a gra of % Power Loss versus paper thickness ('air' gap thickness). Include the zero air gap data previously obtained at $I_s = 0.10$ A in part 2.

In the Conclusion discuss the significance of the shapes of the graphs.

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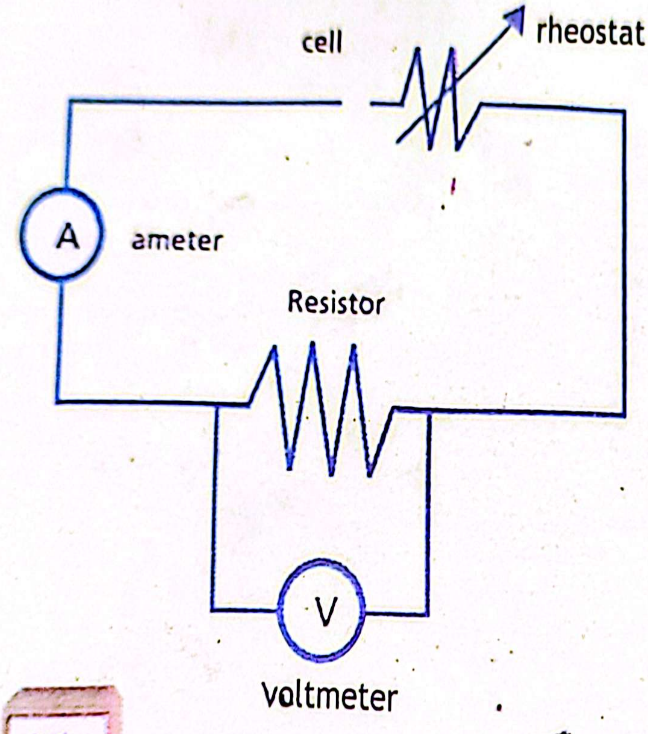

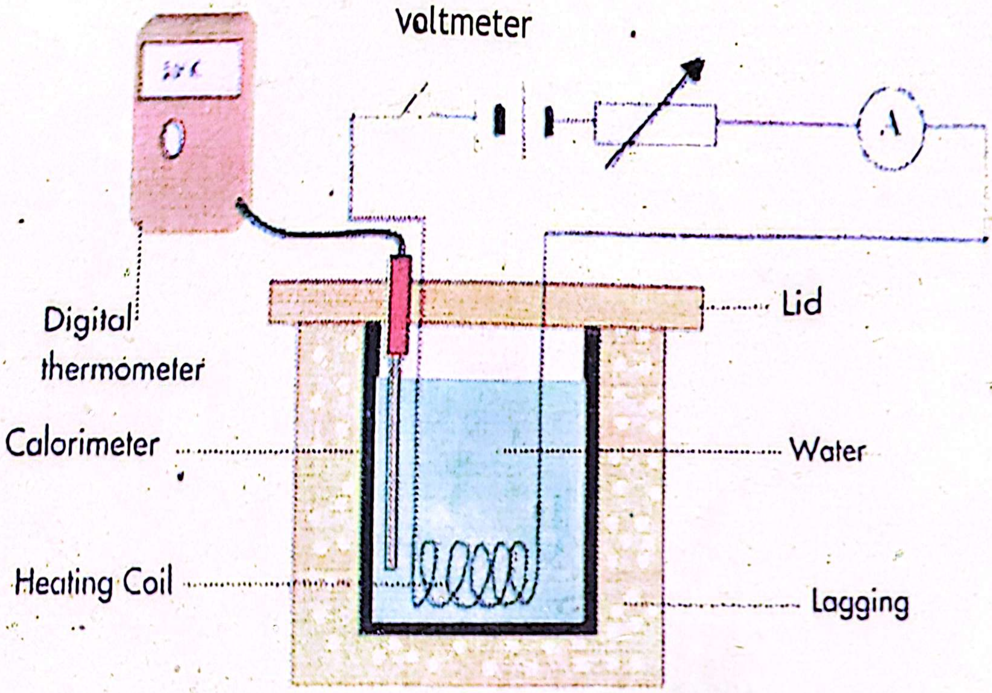

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