ELECTRO-MAGNETISM

Substances are classified into two types
1) Magnetic materials.
2) Non-magnetic materials.

1) Magnetic materials :-

The materials which can attract by the magnets are called magnetic materials.

Ex :- Iron, cobalt, Nickel etc

2) Non-magnetic materials :-

The materials which doesn't attract by the magnets are called non-magnetic materials.

Ex :- Wood, plastic, glass etc.

Natural magnets :-

⇒ The magnets which are available in nature are called natural magnets.

⇒ These are less strength when compared to artificial magnets.

⇒ Natural magnets are irregular in shape.

Ex :- Magnetite.

Artificial Magnets :-

⇒ Man-made magnets are called 'Artificial magnets'

⇒ Artificial magnets have more attractive power.

⇒ Artificial magnets are regular in shape

⇒ These are in different shapes

* Artificial magnets are three types
1) Dia-magnetic substance
2) Para-magnetic substance
3) Ferro-magnetic substance

1) Dia-magnetic substance :-

The substance which repels by the magnets are called dia-magnetic substances.

Ex:- Air, Alcohol, Gold, Water.

2) Para-magnetic substance :-

The substance which attaracts by the magnets are called para-magnetic substances.

Ex:- Oxygen, Platinum etc.

3) Ferro-magnetic substance :-

The substance which are strongly attracted by magnets called ferro-magnetic substance.

Ex :- ferrus, cobalt, nickel etc.

Properties of magnets :

Pole property :-

⇒ Every magnet has two poles north and south

⇒ Even if we cut a small piece of magnet has two poles.

⇒ Isolated poles doesnot exist.

Directionality property :-

⇒ If we suspend a bar magnet it can show only north and south directions.

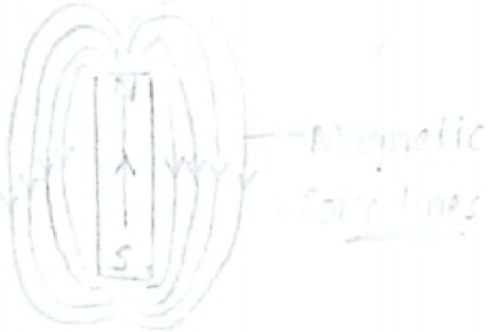
⇒ This property is used in navigation.

Attraction / Repulsion property :-

⇒ Like poles repel each other and unlike poles attract each other.

Magnetic field :-

⇒ The region surrounded by a magnet upto which the force will act by the magnet is called magnetic field.



⇒ The magnetic force lines starts from north pole and end at south pole.

⇒ But inside these lines start from south and end at north pole.

⇒ So, the magnetic lines look like closed loop.

⇒ No two magnetic lines intersect at any point in the magnetic field

⇒ If it intersects it will have two directions but it is not possible

⇒ Where the magnetic lines are more their the strength of magnet is more i.e, at poles

Magnetic flux : (ϕ)

* The number of force lines present in the unit area is called magnetic flux.

* Its units → webers = (wb) → M.K.S
  [A.M] Ampere meter → S.I

* It is denoted by [ϕ]

Magnetic flux density:

The magnetic flux passing through unit normal area perpendicular to the field is called magnetic flux density

$$B = \phi/A$$

$$B = \phi/A\cos\theta$$

$$\phi = BA\cos\theta$$

Units:- Wb/m^2 = Tesla

1 tesla = 10^4 Gauss [C.G.S]

N/A.M

Case-I

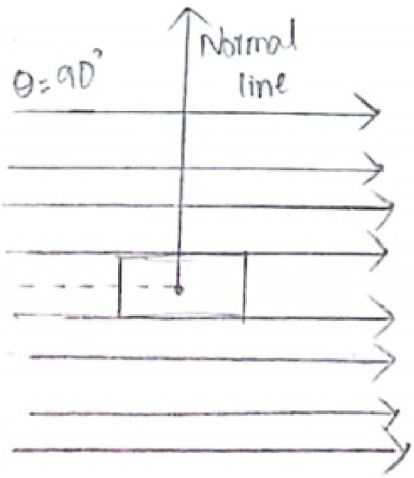
$\theta = 0°$ flux is maximum

Area ⇒ Perpendicular

Case-II

$\theta = 90°$ flux is minimum

Area = Parallel



Oersted

Experiment :- 1

Aim :- Show that every current carrying conductor can produce magnetic field around it.

Apparatus : 1) Thermocol sheet

2) Two sticks with slits

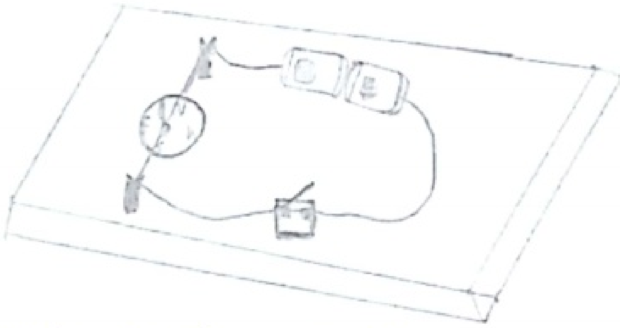
3) Battery

4) Switch

5) Copper wire

6) Bar magnet

7) Compass



Procedure :

1) Arrange the apparatus as shown in the figure.

2) Take compass and barmagnet.

3) Keep the bar magnet near the compass and see the deflection of needle of compass.

4) Place the compass under the copper wire

5) Switch on the circuit and observe the deflection of the compass needle

6) Change the current direction and observe it.

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Observations:-

We observe that when bar magnet placed near the compass the needle of the compass gets deflected.

When compass kept under the copper wire the compass gets deflected.

When we change the current direction the compass deflects in opposite direction.

Because when current passes through copper wire it produces magnetic field around it.

Conclusion :-

By this activity we conclude that every current carrying conductor can produce magnetic field around it.

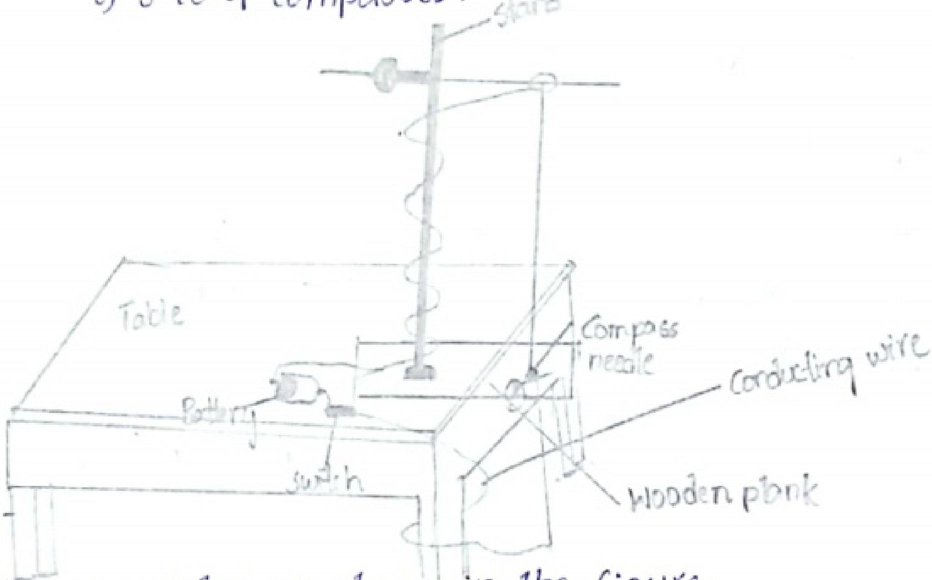
Precautions :-

Do not keep any other magnets near to the experiment.

Experiment:- 2

Aim :- Show that the magnetic field direction is in circle around a straight current carrying conductor.

Apparatus :- 1) Wooden plank with hole
2) Retard stand
3) Copper wire
4) Battery
5) Switch
6) 6 to 9 compasses.



Procedure :-

1) Arrange the apparatus as shown in the figure.
2) See that the copper wire must pass through the hole of the wodden plank.
3) Place 6 to 9 compasses around the hole.
4) Switch on the circuit and observe the deflections in the magnetic needles of a compass.

Observations :-

* We observed that all the magnetic needles of the compass arranged as the tangents of a circle

By this we can say the magnetic force lines are in circle.

Conclusion:-

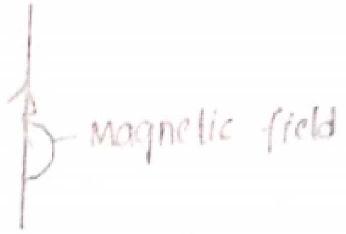
By this experiment we came to know that a straight conductor carrying current can produce magnetic field around it in circular path

Amphere's thumb rule :-

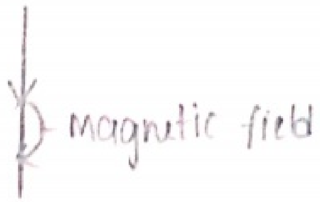
* Amphere explained the direction of magnetic field formed around a current wire.

* According to Amphere rule if we hold a current carrying wire with our right hand the thumb shows the current direction and remaining fingers shows the magnetic field directions.

Ex: 1) If current is moving upwards magnetic field is in anticlockwise direction.



2) If current is moving downwards magnetic field is in clock wise direction



Solenoid :-

* Solenoid is a long copper wire wound in a closed packed helix
* A long coil is called solenoid.

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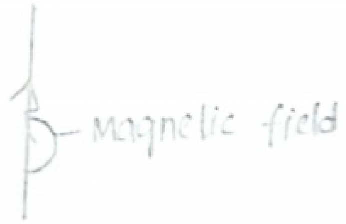


2) If current is moving downwards magnetic field is in clock wise direction

Solenoid :-

* Solenoid is a long copper wire wound in a closed packed helix
* A long coil is called solenoid.

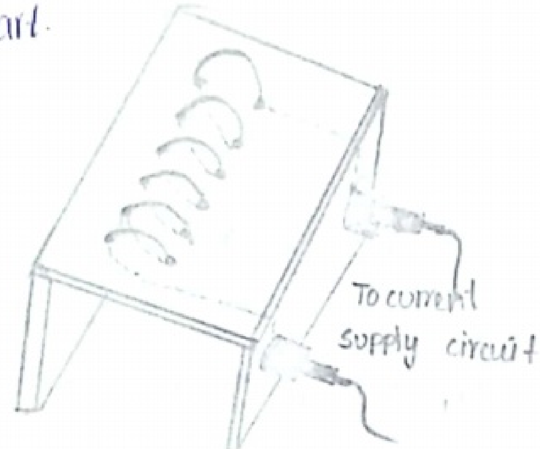
Experiment: 3

Aim :- To prove the magnetic field due to solenoid

(or)

Show that the magnetic field lines are straight if current is in circular path.

Apparatus :- 1) Iron fillings
2) Wodden plant
3) Insulated copper wire
4) Battery
5) Switch
6) White chart.



Procedure :-

1) Take a wodden plank and cover with white paper.
2) Make equidistant holes on the surface of the wodden plank.
3) Pass the copper wire through the holes and make it as solenoid.
4) Connect these two ends of solenoid with battery.
5) Sprinkle the iron fillings around the solenoid.
6) Switch on the circuit and jerk the table.
7) Observe the arrangement of iron fillings.

Observations :-

* I observed that when I jerk the table the iron fillings arrange themselves in order to like a bar magnet.

* When the current is in clockwise in the solenold, there south pole will form

* Where the current is in anti-clock wise in the solenoid, there north pole will form.

* The magnetic force lines will move outside north to south. But inside south to north.

* By this we can explain the magnetic force lines are closed loopes.

* In this way solenoid can act as a bar magnet.

Conclusion :-

By this we can conclude if the current is in circle magnetic field is in straight line.

Force :-

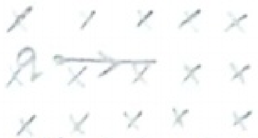
Force acting on a moving charge which is kept in magnetic field.

If charge is at rest that does not create magnetic field around it.

If charge is in motion then it can create magnetic field.

The force

$f = qvB\sin\theta$



q charge is moving with 'v' velocity in 'B' magnetic field.

For maximum force :-

If charge is moving perpendicular to magnetic field then $\theta = 90°$

$\therefore f = qvB\sin\theta$

$\theta = 90°$

$V \perp B$

$F = qvB\sin\theta$

$F = qvB$

$\boxed{F_{max} = qvB}$

For minimum force :-

If the charge is moving parallel to magnetic field than $\theta = 0$

Hence force is minimum

$f = qvB\sin\theta$

$F = qvB.0$

$\boxed{F = 0}$

The force acting on a current carrying conductor which is placed in magnetic field.

i current is passing through conductor of length l in magnetic field B

$F = qvB\sin\theta$

$V = \frac{S}{t}$ or $V = \frac{l}{t}$

$F = q \cdot l/t \sin\theta$ $[q/t = i]$

$\boxed{F = ilB\sin\theta}$

Flemming left hand rule :

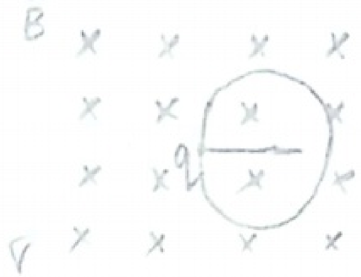
* Flemming explained the direction of force acting on a current carrying wire placed in magnetic field.
* According to flemming if we stretch three fingers thumb shows the force direction, fore finger indicate the magnetic field direction and middle finger indicate current direction.

Ex:-

B = into
i = up
f = left

B = out
i = east
F = south

A charged particle 'q' is moving with a speed 'v' perpendicular to the magnetic field 'B'. Find radius and also time period of the particle



$F = qvB$

centri fugal force

$[f = mv^2/r]$

$mv^2/r = qvB$

$r = \frac{mv^2}{qvB}$

$\boxed{r = m/qB}$

Time period

$v = s/t$

$[s = 2\pi r]$

$v = 2\pi r/t$

$[r = mv/qB]$

$rqB = m.2\pi r/t$

$\boxed{T = 2m\pi/qB}$

Experiment-4:-

Aim:- show that the force acting on a current wire when it is placed in magnetic field

(or)

show when hore-shoe magnet keep near to the current wire some force acting on wire.

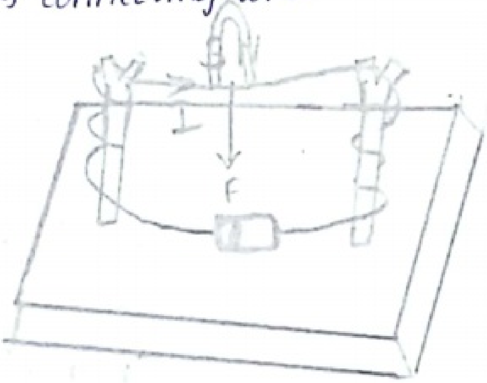
Apparatus:- 1) Wodden plank

2) Two sticks with slits

3) Hore-shoe magnet

4) Battery

5) connecting wires.



Procedure:-

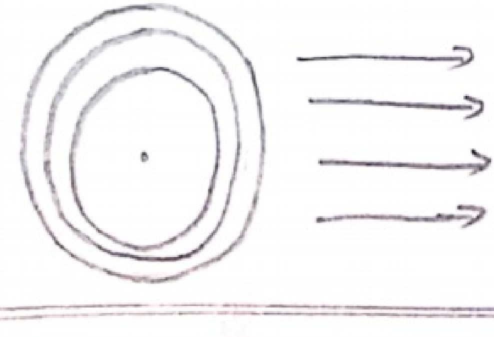
1) Take a wodden plank and fix two sticks with slits

2) A copper wire pass through the slits and two ends connected to a battery along with the switch.

3) Close the switch and bring hore-shoe magnet near to the copper wire

4) Now, observe the deflection of the copper wire.

Observations:



I observed that when current pass through the wire if it is into the paper according to Amphere rule to the magnetic field will form in clock-wise direction

And shoe magnet can form with uniform magnetic field north-south.

When hore-shoe magnet brought near to the current wire the magnetic field lines co-incide

At upper part both magnetic field lines are some direction so the intensity will increase.

At lower part both magnetic field lines are opposite in direction so the intensity will decrease.

So it forms non-uniform magnetic field. Upper part is strong and lower part is weaker.

So the wire will move strong region to weak region [down]

Conclusion :-

By this activity we conclude that when hore-shoe magnet brought near to current wire the wire will deflect.

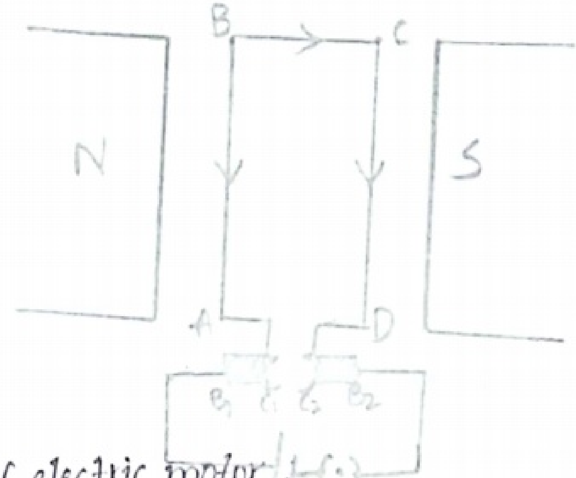
Electric Motor :-

The device which convert electrical energy to mechanical energy.

Working principle :-

Electric motor works on the principle of a current carrying wire placed in magnetic field it experiences the force.

Construction :- 1) Armature.
2) Magnetic field.
3) Split rings (Cummulators) change current direction.
4) Carbon brush.
5) Battery.



Working of electric motor :-

1) When we switch on the battery the current pass through B_1C_1 to AB and coming through CD to C_2B_2

2) In AB and CD the current directions are opposite these are experienced the force due to magnetic field.

3) According to flemming left hand rule AB pushes downwards and CD pushes upwards.

4) In this way coil rotates in anti-clock wise direction.

5) When it rotates 90° the current will cut off. B_1 will not be in contact with C_1 and B_2 not in contact with C_2.

6) But according to law of Newtons inertia of motion the coil rotates anothe 90°

7) Now B_1 will be in contact with C_2 and B_2 in contact with C_1.

8) Again current passes through B_1C_2 and DC and coming through BA to C_1B_2

9) According to left hand rule CD pushes again down AB pushes upwards.

10) In this way the coil continuosly rotates in anti-clock wise direction.

<u>Factors on which the speed of the motor depends</u>

1) Number of coils in the armature.
2) Area of coil.
3) The magnitude of current.
4) The strength of the magnets.

T.V screen destroyed when a bar magnet brought near to the screen. Give the reasons.

This is due to the fact magnetic field exerts a force on a moving charge which is on the screen.

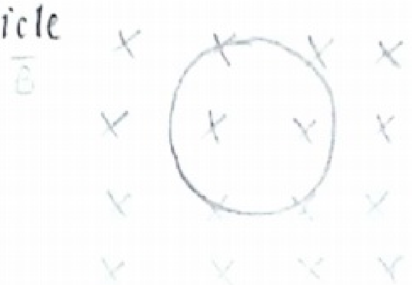
<u>Explaination</u> :-

Picture on screens means electrons reaching the screen. These are effected by the magnetic field produced by the bar magnet. So the picture will be destroyed when we keep the bar magnet near to the screen.

The force on moving charge is due to the magnetic field

$F = qVB$.

A charged particle 'q' is moving with a speed 'v' perpendicu to the magnetic field 'B'. Find radius and also time period of the particle



$F = qvB$

centrifugal force

$F = mv^2/r$

$mv^2/r = qvB$

$r = mv^2/qvB$

$r = mv/qB$

Time period

$V = S/T$

$S = 2\pi r$

$V = 2\pi r/T$

$r = mv/qB$

$rqB = mv$

$rqB = m.2\pi r/T$

$T = 2m\pi/qB$

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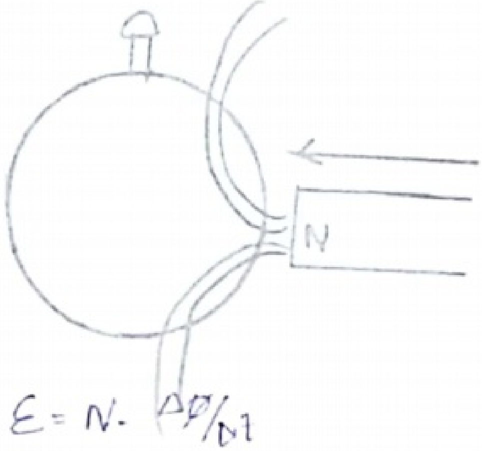
Faraday's electromagnetic induction :-

"when there is a continuous magnetic flux change linked with closed loop it can create current that current is called Induced current. this phenomenon is called electromagnetic induction."



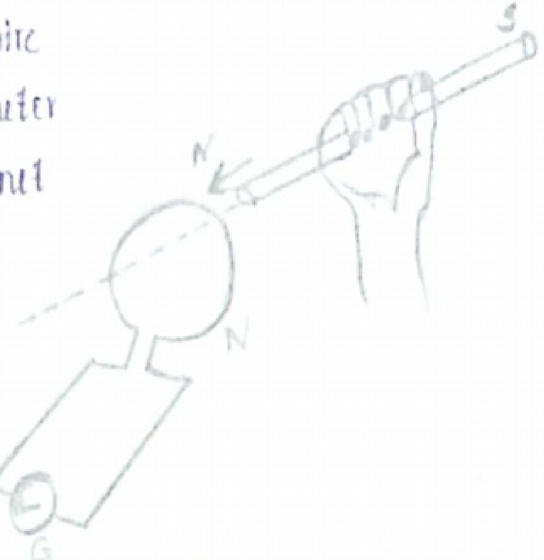
$\varepsilon = \Delta\phi/\Delta t$

$\varepsilon = d\phi/dt$ $\quad\varepsilon = N \cdot \Delta\phi/\Delta t$

Experiment - 5

Aim:- To understand Faraday's Electromagnetic induction

Apparatus:-
1) Copper wire
2) Galvanometer
3) Bar magnet



Procedure:-

1) Arrange the apparatus as shown in the figure with galvanometer

2) Now take a bar magnet and push towards the coil (and observe with its north pole facing the coil and observe the deflection in galvanometer.

3) Take the bar magnet away from the coil and observe the deflection in galvanometer

4) Now take the bar magnet and push towards the coil with south pole and observe the deflection in galvanometer.

5) And take the magnet away from the coil and observe the deflection.

6) Keep the bar magnet near to the coil at rest and observe the deflection in galvanometer.

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Observations :-

* I observed that when we push the north pole towards the coil, galvanometer needle deflects one side.

* When we push with southpole the needle deflects opposite side and when we take back, the needle comes to same place.

* When we place a bar magnet near a copper wire galvanometer doesn't defflect because there is no change in the flux.

Conclusion :-

By this I conclude that, with magnet we can prepare current by changing flux.

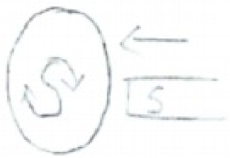
Lenz Principle :-

He explained the direction of Induced current. "The Induced current will appear in such a direction that it opposes the change in the flux in the coil."

$$\varepsilon = -N \cdot d\phi / dt$$

When we push north pole towards the coil. The Induced current direction is anti-clockwise

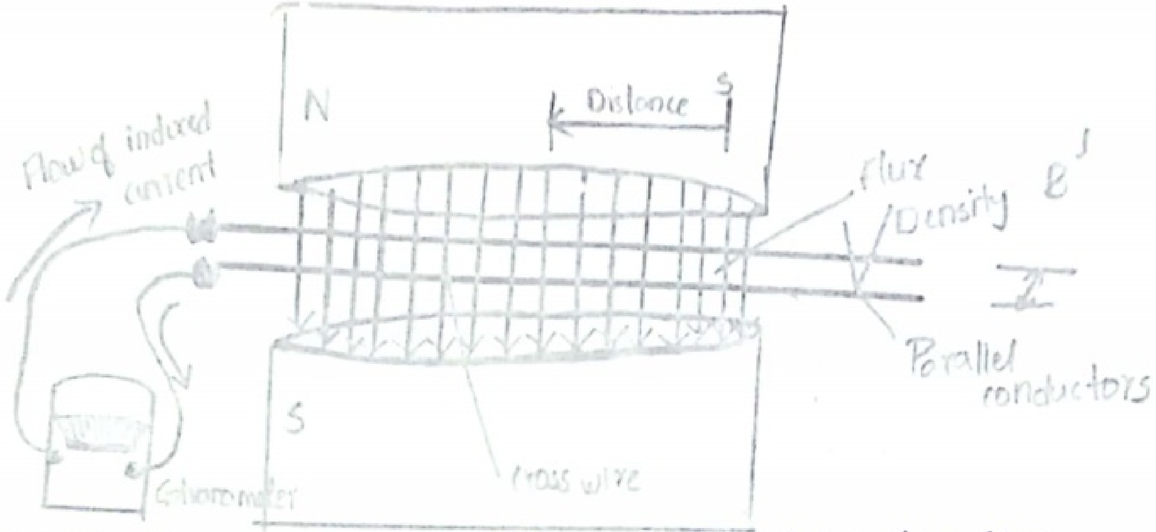
When we push south pole away from the coil. The Induced current direction is clock-wise



When we push south pole towords the coil. The Induced current direction is clockwise

When we push south pole away from the coil. The Induced current direction is Anti-clock wise

Derivation of Faraday's law :-



Arrange the apparatus as shown in the figure place two conductors parallel to each other with length "l" and distance "s" between two magnetic poles.

these two conductors are connected to a galvanometer, now take a cross wire between two parallel conductors and move left to right Then the galvanometer needle deflects.

On the basic principle of conservation of energy the work done by moving cross wire is equals to Induced current produced in it.

Derivation :-

The work done by rod while moving $W = F.S$

$W = F.S$ —(1)

But $F = ilB$ —(2)

From eq (1) and (2)

$W = F.S$

$W = ilB.S$ —(3)

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But we know that

$B = \phi/A$ | A = area, ϕ =

We also know that

$A = l \cdot S$

$\therefore B = \frac{\phi}{l \cdot S}$

$\boxed{\phi = B l S}$ — (4)

From eq (3) & (4)

$W = i l \underline{BS}$

$W = i\phi$

Power (P) = W/t

$\therefore P = W/t = i\phi/t$

$\boxed{P = i \cdot \varepsilon}$ — (5) $[\varepsilon = \phi/t]$

This is work done by mechanical

The work done by electricity is

$W = F \cdot S$

$W = ilBs$

$P = W/t \Rightarrow P = \frac{ilBS}{t}$

$P = ilB(V)$ $[V = S/t]$

$\boxed{P = ilBV}$ — (6)

According to law of conservation eq (5) and eq (6) is equal i.e, Eq 5 = Eq 6

$\cancel{i} \cdot \varepsilon = \cancel{i} lBV$

$\boxed{\varepsilon = lBV}$

Lenz law

A Russian physicist Henrich Lenz states that "the induced current will appear in such a direction that it opposes the changes in the flux in the coil"

Lenz assumed that when a bar magnet pushed towards a coil with its north pole facing. So induced current is produced in the coil let the direction of current in the coil be in clockwise.

Current is in clockwise direction forms south pole. Then the north pole of the bar magnet and south pole of coil get attracted. Then it gains kinetic energy.

But this is contradictory to conversation of energy so the direction of induced current is wrong, the direction of induced current has to be in anticlock wise direction with respect to North Pole of the bar margnet.

The North pole of bar magnet is repelled by the northpole of the coil. Hence we need to work against to over come the repulsion force.

When we pull the bar magnet away from the coil with north pole facing the coil

In this case the coil opposes the motion of the bar magnet to balance to the conservation of mechanical energy into energy. This happens only when the north pole of the magnet faes the south of the coil

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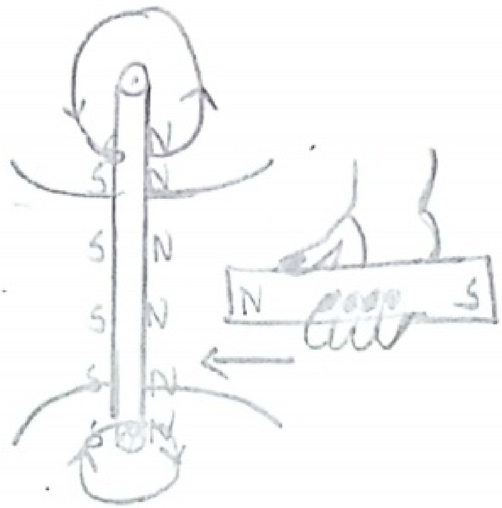


Applications of Faraday's Principle :-

1) Security Check
2) Induction stove
3) A.T.M card [swiping card]
4) Tape recorder
5) Generator

1) Security check :-

* During security check people are made to walk through a large upwright coil of wire which produces a weak A.C magnetic field.

* If we carry any material which is made by Iron or any other metals then the magnetic flux linked with the large coil changes and Induced current is generated in the coil.

* This gives the bulb and makes to trigger alarm.

2) **Induction stove:-**

* Induction stove works with the principle of electromagnetic Induction
* A metal coil is kept beneath cooking surface
* It carries A.C current which produce A.C magnetic field.
* When we place a metal pan on cooking surface This leads to change in the magnetic field under the metal container so it produces Induced E.M.F and this area can heat because of highest resistance.
* This change of magnetic field (Induced current) produces Induced current and coil gets heated.
* This heat is supplied to conductor and therefore cooking is possible.

3) **Swiping card:-**

* A.T.M card work on the principle of electromagnetic Induction
* When we swipe the card the black strip which made of magnetic material helps in changing flux.
* By this it can create Induced E.M.F
* So it can read all the details of the person's account.

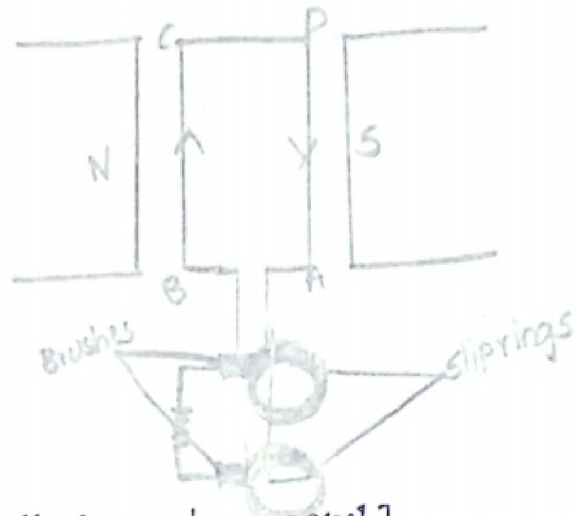
AC Generator working principle

* The device which convert mechanical energy to electrical energy.

Working Principle :-

Generator works on the principle of electromagnetic Induction.

Construction:-



1) Magnetic field [Horse-shoe magnet]
2) Armature [A, B, C, D copper wire in rectangular shape]
3) slippering
4) Carbon brushes
5) Load resistance [Appliance]

Working

1) Arrange the apparatus as shown in the figure
2) Imagine coil is in the vertical position A is top B is bottom. In this position flux is zero then Induced current [E.M.F] is zero.
3) If we rotate armature 90° in clockwise, the coil is in horizontal, A is right side, B is left side. Now the flux change from 0 to maximum so the Induced EMF is maximum.

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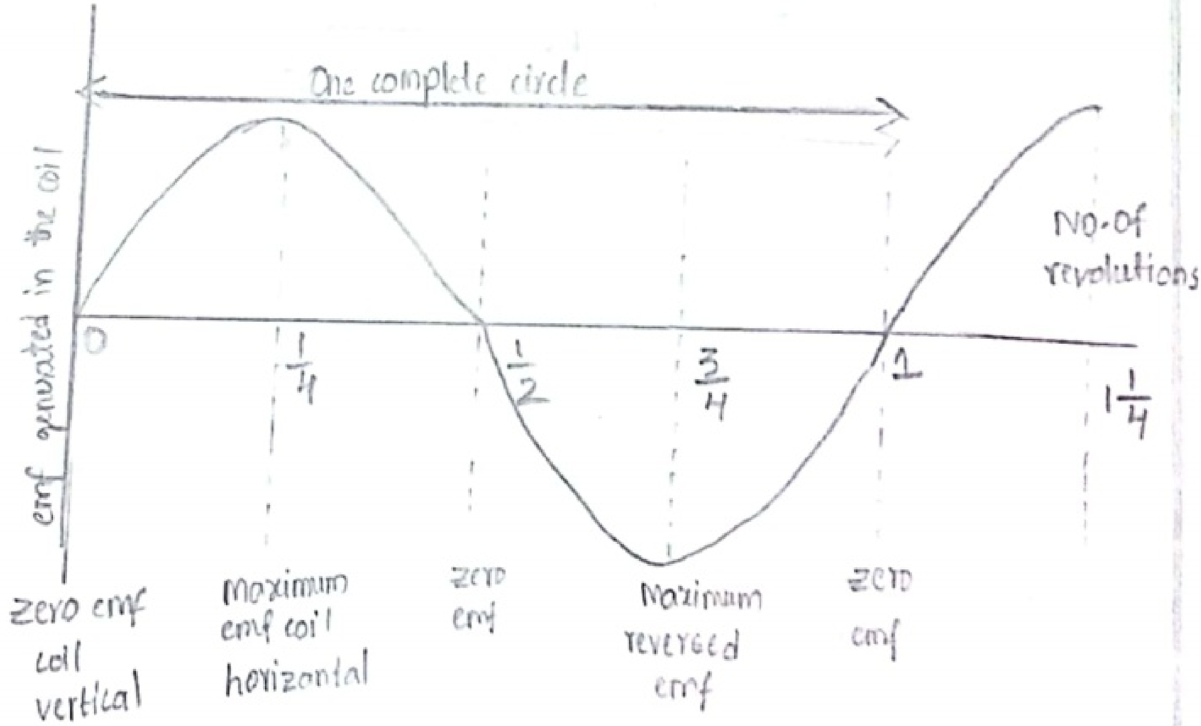
) When it rotate again 90° in clock-wise direction now the coil is in vertical B is top A is down. Flux change to maximum to 0. Hence the Induced EMF is zero.

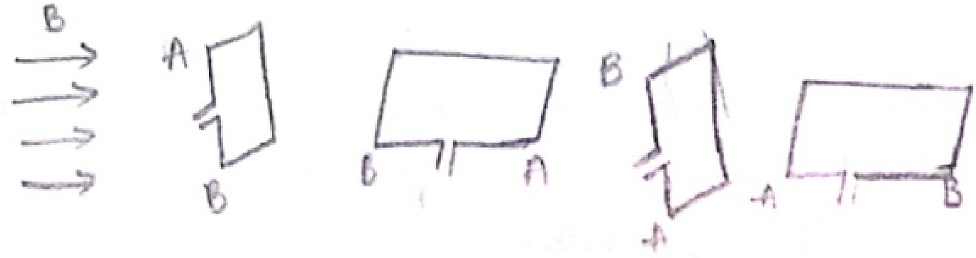
Now it rotate again 90° in clockwise direction A is left side B is right side now the coil is in horizontal the flux change zero to maximum in negative direction.

Again if it rotate in 90° the coil is in vertical A is top B is bottom the flux change is maximum to zero. Hence the Induced EMF is 0.

In this way if we rotate the coil continuously due to change in flux it can create the current.



Position of coil in one rotation



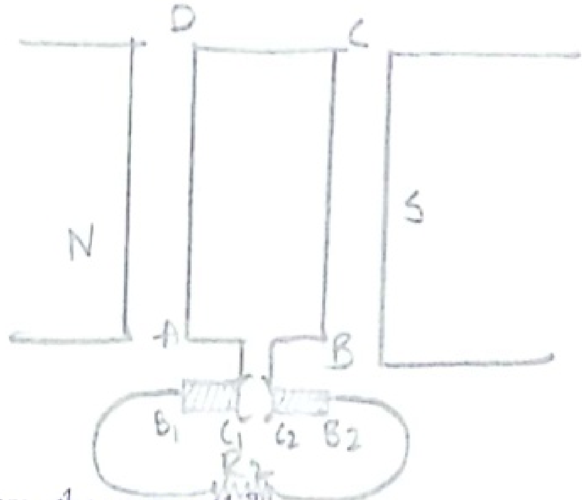
DC Electric Generator :-

The device which current mechanical energy into electrical energy.

Working principle :-

Generator works on the principle of electromagnetic induction

Construction :-



1) Magnetic field [Hore-shoe magnet]
2) Armature
3) Spit rings
4) Carbon brushes
5) Load resistance

Working

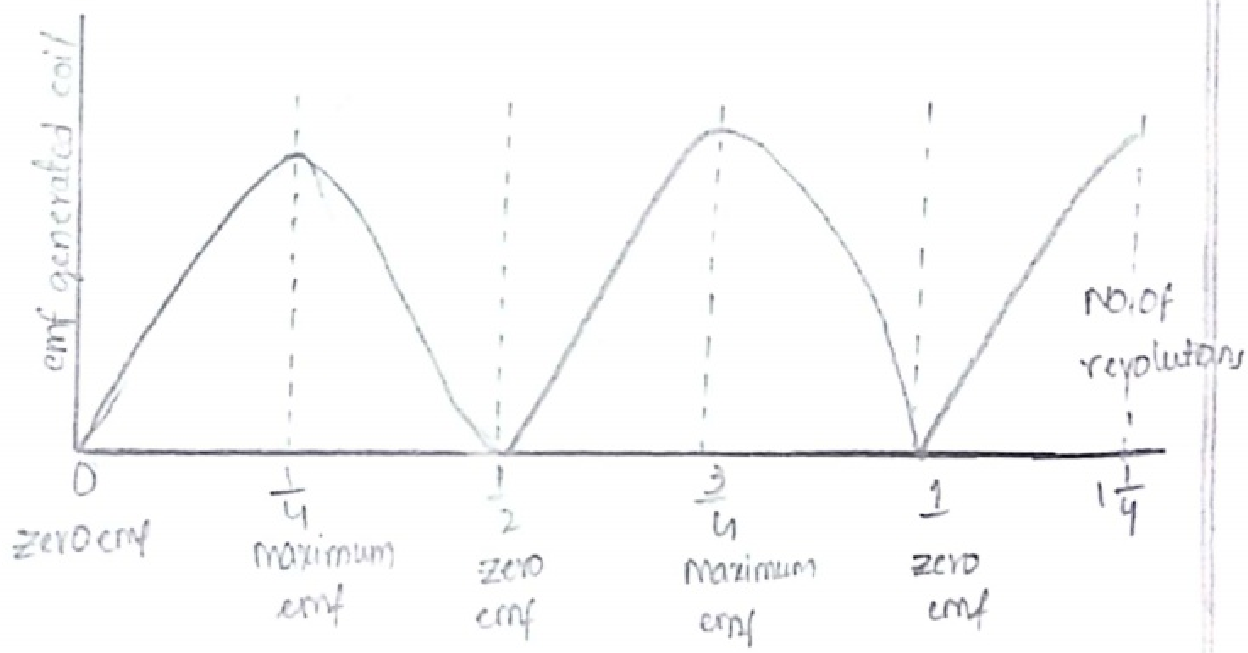
1) Arrange the apparatus as shown in the figure
2) Imagine the coil is in vertical position, A is top, B is bottom. In this position the induced EMF is 0
3) If we rotate 90° in clockwise direction the coil is in horizantal A is right side and B is left side. In this position the Induced EMF is maximum. In this way for the first half rotation the induced current zero to maximum and maximum to zero.

If we rotate further half rotation the current is reversed in the coil itself because as the coil moves another half rotation the position of split rings changes.

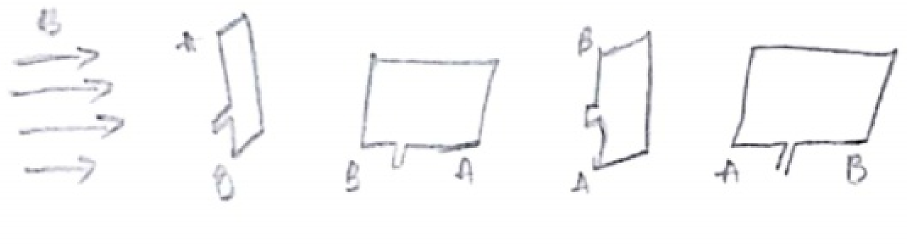
For next half rotation the current is generated identical to first half.

In this way it produces / generators D.C current.

The D.C current frequency is zero.



Position of the coil in one rotation



What are the advantages of A.C current over D.C

* AC current is less expensive to prepare and easy to supply than D.C
* AC current can transmit over a long distance than DC current
* During transmition of AC current the power loss is very less.