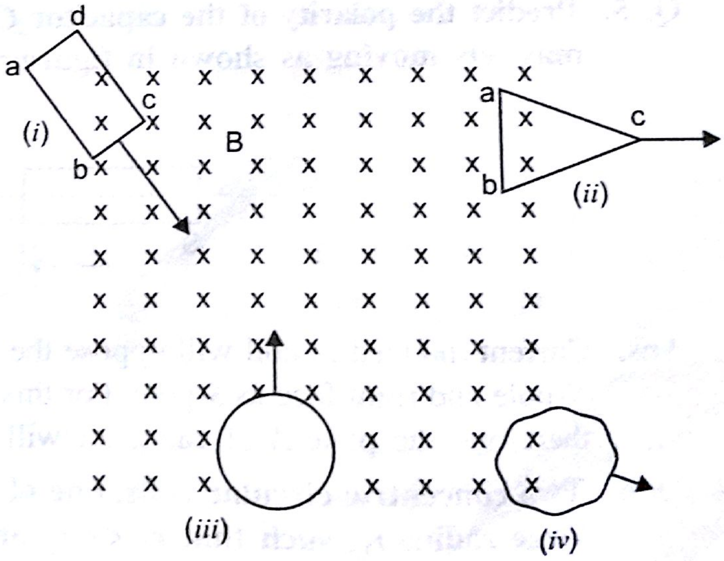
NCERT QUESTIONS

Q. 1. Figure shows planar loops of different shapes moving out of or into a region of magnetic field which is directed normal to the plane of loops downwards. Determine the direction of induced current in each loop using Lenz's law. *[CBSE (AI) 2010]*



Ans. (*a*) In Fig. (*i*) the rectangular loop *abcd* and in Fig. (*iii*) circular loop are entering the magnetic field, so the flux linked with them increases; The direction of induced currents in these coils, will be such as to oppose the increase of magnetic flux; hence the magnetic field due to current induced will be upward, *i.e.,* currents induced will flow *anticlockwise.*

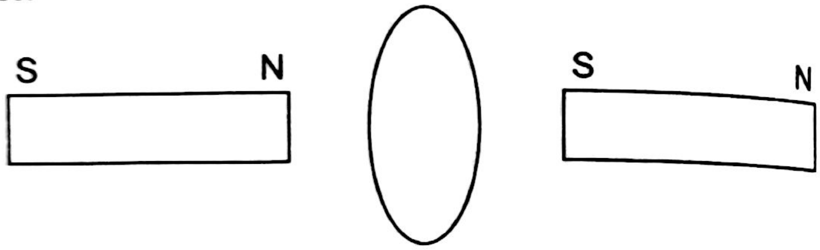
(*b*) In Fig. (*ii*), the triangular loop *abc* and in fig. (*iv*) the zig-zag shaped loop are emerging from the magnetic field, therefore magnetic flux linked with these loops decreases. The currents induced in them will tend to increase the magnetic field in downward direction, so the currents will flow *clockwise.*

Thus in fig. (*i*) current flows anticlockwise, in fig. (*ii*) current flows clockwise,

in fig. (*iii*) current flows anticlockwise,

in fig. (*iv*) current flows clockwise.

Q. 2. A closed loop is held stationary in the magnetic field between the north and south poles of two permanent magnets held fixed. If the magnets are strong, will the current be generated in the loop?



Ans. No. This is because the magnetic flux linked with the coil will remain constant if magnets and coil are stationary, however strong the magnets may be.

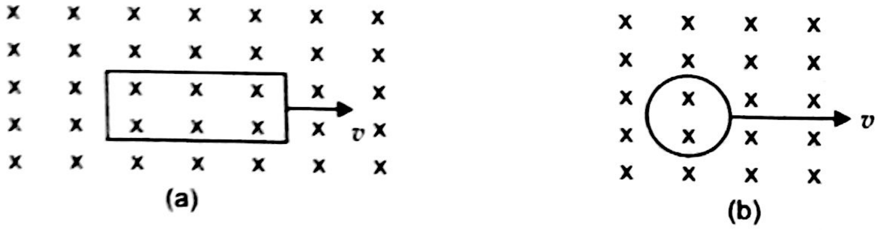
Q. 3. A closed loop moves normal to constant electric field between the plates of a large capacitor. Is the current induced in loop (*i*) when it is wholly inside the region between the capacitor plates. (*ii*) when it is partially outside? The electric field is normal to the plane of the loop.

Ans. No. This is because current cannot be induced by changing the electric flux linked with the coil.

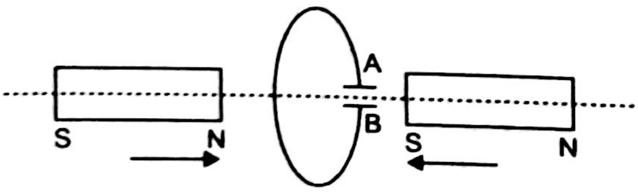
Q. 4. A rectangular loop and a circular loop are moving out of a uniform magnetic field region to a field free region with a constant velocity. In which loop do you expect the induced emf to be a constant during the passage out of the field region? The field is normal to the loop.

[CBSE (AI) 2010]

Ans. In rectangular coil the induced emf will remain constant because in this the case rate of change of area in the magnetic field region remains constant, while in circular coil the rate of change of area in the magnetic field region is not constant.

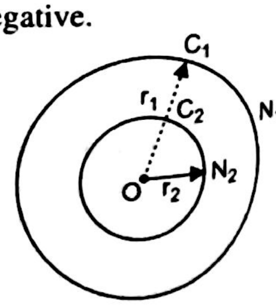


Q. 5. Predict the polarity of the capacitor *C* connected to coil, which is situated between two bar magnets moving as shown in figure. ***[CBSE Delhi 2011]***



Ans. Current induced in coil will oppose the approach of magnet; therefore, left face of coil will act as *N*-pole and right face as *S*-pole. For this the current in coil will be anticlockwise as seen from left, therefore, the plate *A* of capacitor will be positive and plate *B* will be negative.

Q. 6. Two concentric circular coils, one of small radius r_2 and the other of large radius r_1, such that $r_2 << r_1$ are placed co-axially with centres coinciding. Obtain the mutual inductance of the arrangement.



Ans. Mutual Inductance of two plane coils: Consider two concentric circular plane coils C_1 and C_2 placed very near to each other. The number of turns in the primary coil is N_1 and radius is r_1 ; while the number of turns in the secondary coil is N_2 and its radius is r_2. If I_1 is the current in the primary coil, then magnetic field produced at its centre,

$$B_1 = \frac{\mu_0 N_1 I_1}{2r_1} \quad \text{...(i)}$$

If we suppose this magnetic field to be uniform over the entire plane of secondary coil, then *total effective magnetic flux linkage* with secondary coil

$$\Phi_2 = N_2 B_1 A_2 = N_2 \left(\frac{\mu_0 N_1 I_1}{2r_1} \right) A_2$$

$$= \frac{\mu_0 N_1 N_2 A_2}{2r_1} I_1$$

By definition, *Mutual Inductance*, $M = \frac{\Phi_2}{I_1} = \frac{\mu_0 N_1 N_2 A_2}{2r_1}$

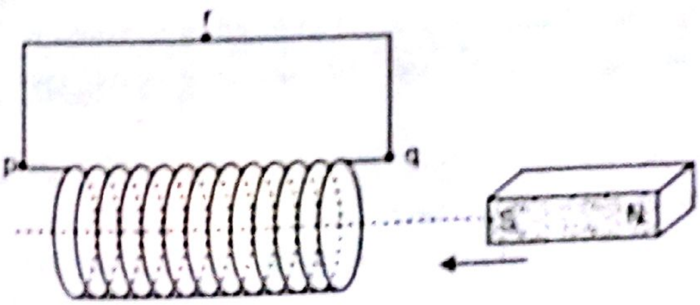
But $\quad A_2 = \pi r_2^2$

$$\therefore \quad M = \frac{\mu_0 N_1 N_2 \pi r_2^2}{2r_1}$$

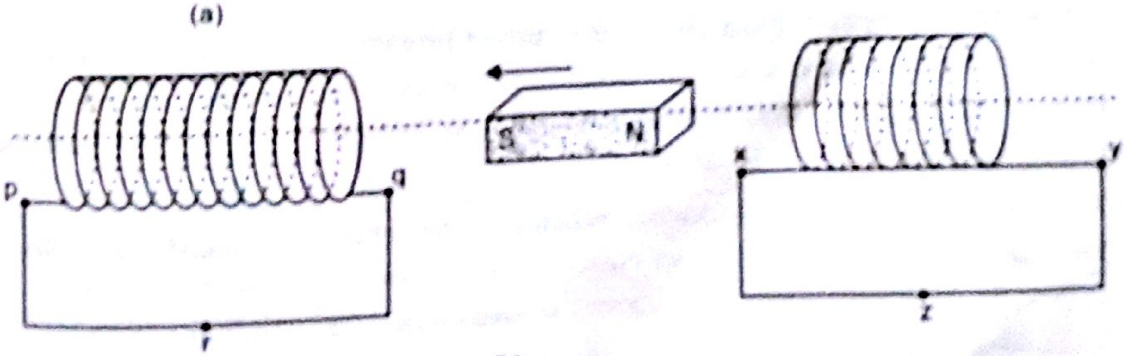
Special case : If both coils have one turn each; then $N_1 = N_2 = 1$

so mutual inductance $M = \frac{\mu_0 \pi r_2^2}{2r_1}$

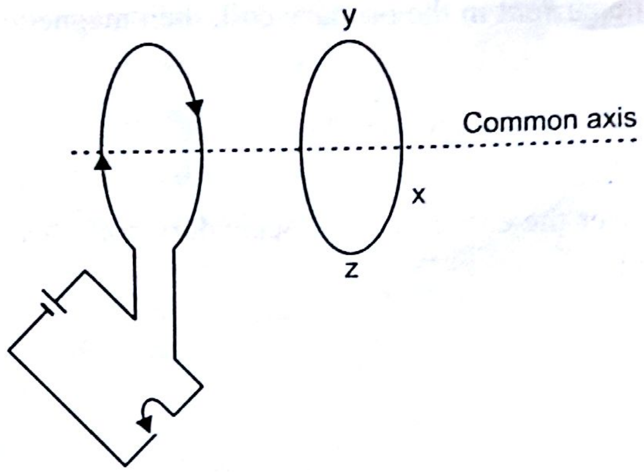
Q. 7. Predict the direction of induced current in the situations described in the following figs.



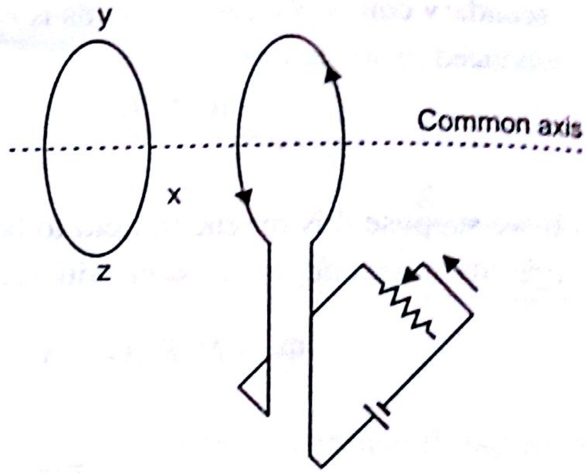
(a)



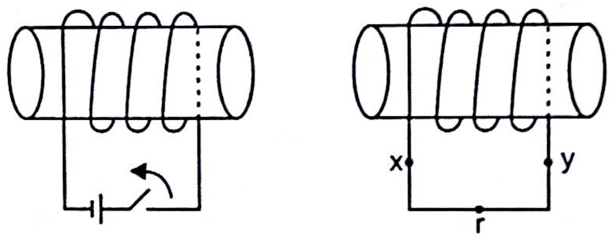
(b)



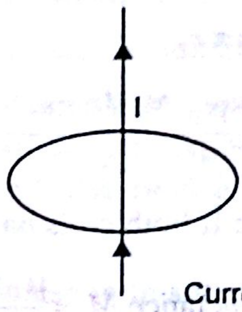
(c) Tapping key just closed



(d) Rheostat setting being changed



(e)
Tapping key just released



(f) Current (I) decreasing at a steady rate

Ans. (*a*) The direction of current is along *qrpq* because the current induced in solenoid will oppose the approach of magnet, so from looking on magnet side the current at nearer face should flow clockwise.

(*b*) In this case the current induced in coil *pq* will oppose the approach of magnet while coil *xy* will oppose the recession of magnet; so nearer faces of coils will act as *S*-poles. Accordingly the direction of current in coil *pq* will be along *qrp* and in coil *xy* it will be along *yzx*.

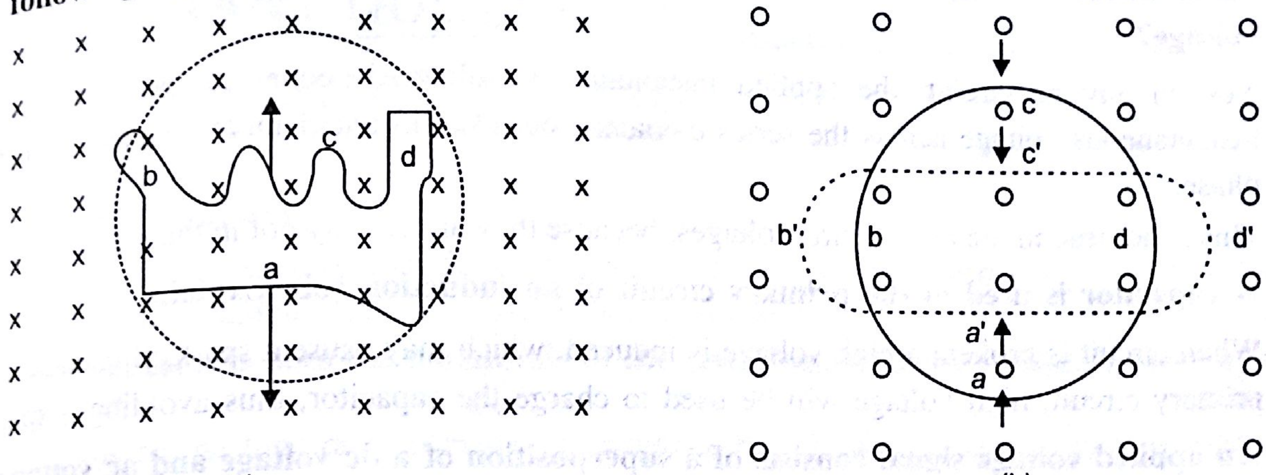
(*c*) When the tapping key is just closed, the current produced in the left loop flows clockwise, so magnetic field induced will flow along negative axis; the current induced in right coil will oppose the magnetic field produced, so current in right coil will flow anticlockwise, *i.e.*, direction of current will be along *yzx*.

(*d*) The current in coil is anticlockwise. When rheostat setting is being changed, the resistance of the right circuit is decreasing, so current is increasing, the current induced in left loop will oppose the increase of current, so current induced in left coil will flow clockwise *i.e.*, along *zyx*.

(*e*) Induced current in the right coil is along *xry*.

(*f*) No induced current because magnetic field lines lie in the plane of loop.

Q. 8. Use Lenz's law to determine the direction of induced current in the situation described by following figs.



(a) (b)

(*a*) **A wire of irregular shape turning into a circular shape.**

(*b*) **A circular loop being deformed into a narrow straight wire.**

Ans. (*a*) For the given periphery the area of a circle is maximum. When a coil takes a circular shape, the magnetic flux linked with coil increases, so current induced in the coil will tend to decrease the flux and so will produce a magnetic field upward. As a result the current induced in the coil will flow anticlockwise *i.e.,* along *adcb*.

(*b*) For given periphery the area of circle is maximum. When circular coil takes the shape of narrow straight wire, the magnetic flux linked with the coil decreases, so current induced in the coil will tend to oppose the decrease in magnetic flux; hence it will produce upward magnetic field, so current induced in the coil will flow anticlockwise *i.e.,* along $a'\ d'\ c'\ b'$.

A.C. Circuits

Q. 9. Power factor can often be improved by the use of a capacitor of appropriate capacitance in the circuit. Explain.

Ans. Power factor, $\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + X^2}}$

The net reactance $X = X_L \sim X_C$.

Many ac machines have inductive reactance. The net reactance can be reduced by using a capacitor of appropriate capacitance which will make $X_C\left(=\frac{1}{\omega C}\right)$ equal to $X_L\ (=\omega L)$, so that $X \to 0$ and $Z \to R$, then power factor $\cos\phi = \frac{R}{Z}$ will attain the maximum value.

Q. 10. A lamp is connected in series with a capacitor. Predict your observation for dc and ac connections. What happens in each case if the capacitance is reduced?

Ans. For dc connections, the lamp will shine momentarily and in steady state a capacitor acts as an open circuit, hence lamp will not shine.

For ac connections the lamp shines because current $I = \frac{V_{rms}}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}}$ is finite. When capacitance is reduced, $\frac{1}{\omega C}$ will increase, so current will decrease and brightness of lamp will decrease.

Q. 11. In any ac circuit, is the applied instantaneous voltage equal to the algebraic sum of the instantaneous voltages across the series elements of the circuit? Is the same true for rms voltage?

Ans. Yes, in any ac circuit, the applied instantaneous voltage is equal to the algebraic sum of instantaneous voltage across the series elements, because instantaneous voltages are in the same phase.

This is not true in the case of rms voltages, because they are usually not in the same phase.

Q. 12. A capacitor is used in the primary circuit of an induction coil. Explain.

Ans. When circuit is broken, a high voltage is induced, which may cause a spark. If capacitor is in the primary circuit, high voltage will be used to charge the capacitor, thus avoiding a spark.

Q. 13. An applied voltage signal consists of a superposition of a dc voltage and ac voltage of high frequency. The circuit consists of an inductor and a capacitor in series. Show that the dc signal will appear across C and the ac voltage across L.

Ans. Inductive reactance $X_L = \omega L$

Capacitive reactance $X_C = \dfrac{1}{\omega C}$

For dc in steady state $\omega = 0; X_L = 0, X_C = \infty$ (for dc).

Thus the inductive reactance has zero value for dc and very high value for high frequency ac. On the other hand capacitance offers infinite reactance to dc and very low reactance to high frequency ac.

So when inductor and capacitor are connected in series, the capacitor gives easy path to ac and does not allow dc; while inductor gives easy path to dc and offers very high hindrance to ac. Hence, dc signal will appear across C and ac voltage across L.

Q. 14. A choke coil in series with a lamp is connected to a dc line. The lamp is seen to shine brightly. Insertion of an iron core in the choke causes no change in lamp's brightness. Predict the corresponding observations if the connection is to an ac line.

Ans. Choke coil is a coil of high inductance. It does not offer hindrance to dc; so though insertion of iron core increases the inductance; but due to no hindrance offered by inductor to dc, the current in lamp remains unchanged, so brightness of lamp remains unchanged.

In the case the lamp is connected to ac line, the insertion of iron core will increase inductance and hence inductive reactance $X_L = \omega L$ to a high value; due to this lesser current will flow in the lamp and the brightness of the lamp will be reduced.

Q. 15. Why is choke coil needed in use of fluorescent tubes with ac mains? Why can we not use an ordinary resistor instead of choke coil?

Ans. Choke coil is a coil of high inductance and negligible resistance. It is used to control ac current with negligible power loss because power factor of choke coil $\cos\phi = \dfrac{R}{\sqrt{R^2 + (\omega L)^2}}$ is negligible.

If pure resistor is used in ac circuit, it will absorb the maximum power because power factor of resistor is maximum equal to 1.

VERY SHORT ANSWER QUESTIONS

Previous Years' Questions

Q. 1. Write S.I. unit of magnetic flux. Is it a scalar or a vector quantity. *[CBSE Delhi 2003]*

Ans. S.I. unit of magnetic flux is weber. It is a scalar quantity.

Q. 2. On what factors does the magnitude of the emf induced in the circuit due to magnetic flux depend? *[CBSE (F) 2013]*

Ans. Depends on the time rate of change in magnetic flux (or simply change in magnetic flux)

$$|\varepsilon| = \frac{\Delta\phi}{\Delta t}$$

Q. 3. Define the term self-inductance of a coil. Give its S.I. unit.

[CBSE Delhi 2009; (AI) 2010, 2005, 2004C; (F) 2002]

Ans. The self inductance is defined on the magnetic flux linked with the coil when unit current flows through it.

OR

The self inductance is defined as the emf induced in the coil, when the rate of change of current in the coil is 1 ampere/second.

The unit of self-inductance is henry (H).

Q. 4. Define 1 henry. *[CBSE Delhi 2003]*

Ans. 1 henry is self inductance of that coil in which 1 volt emf is produced when the rate of change of current in that coil is 1 A/s.

Q. 5. How does the self-inductance of an air coil change, when (*i*) the number of turns in the coil is decreased (*ii*) an iron rod is introduced in the coil. *[CBSE Delhi 2003]*

Ans. (*i*) Self inductance of a coil $\propto N^2$

When number of turns in coil is decreased, the self inductance will decrease.

(*ii*) When an iron rod is introduced in the coil, the self-inductance of coil increases.

Q. 6. If the number of turns in the solenoid is doubled, keeping other factors constant, how does the self-inductance of the coil change?

Ans. Self inductance of solenoid $\propto N^2$, so by doubling the number of turns, the self inductance becomes 4-times.

Q. 7. Write an expression for the energy stored in an inductor of inductance '*L*', when a steady current is passed through it. Is the energy electric or magnetic? *[CBSE Delhi 2004C]*

Ans. Energy stored in inductor $U = 1/2\, L I^2$. It is stored as magnetic energy.

Q. 8. How does the mutual inductance of a pair of coils change when

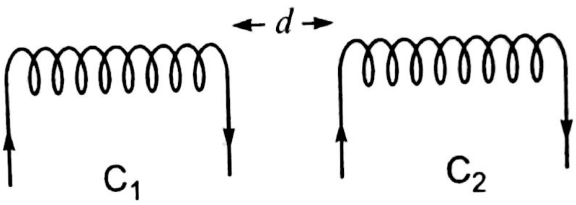
(i) distance between the coils is increased and

(ii) number of turns in the coils is increased? *[CBSE (AI) 2013]*

Ans. (*i*) Mutual inductance decreases.

(*ii*) Mutual inductance increases.

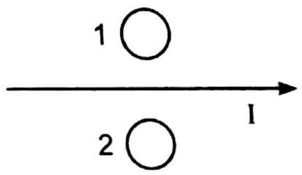
Concept: (*i*) If distance between two coils is increased as shown in figure,



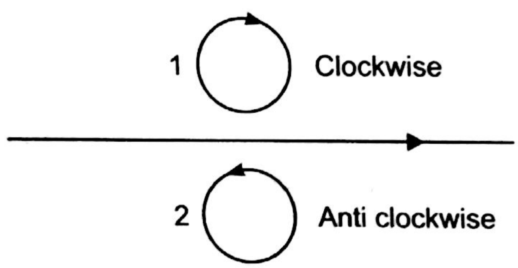
It causes decrease in magnetic flux linked with the coil C_2. Hence induced emf in coil C_2 decreases by relation $\varepsilon_2 = \frac{-d\varphi_2}{dt}$. Hence mutual inductance decreases.

(*ii*) From relation $M_{21} = \mu_0 n_1 n_2 Al$, if number of turns in one of the coils or both increases, means mutual inductance will increase.

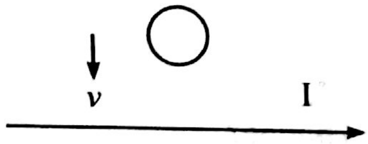
Q. 9. Predict the directions of induced currents in metal rings 1 and 2 lying in the same plane where current I in the wire is increasing steadily. *[CBSE Delhi 2012]*



Ans.

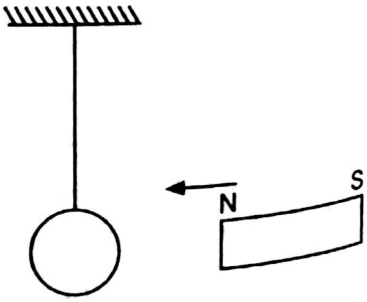


Q. 10. Predict the direction of induced current in a metal ring when the ring is moved towards a straight conductor with constant speed *v*. The conductor is carrying current *I* in the direction shown in the figure. *[CBSE Delhi 2012]*



Ans. Clockwise.

Q. 11. Give the direction in which induced current flows in the wire loop, when the magnet moves towards the loop as shown.



Ans. The current induced in the coil will oppose the approach of magnet, so this nearer face of the coil will act as north pole; therefore on viewing from the magnet side the current in the coil will be **anticlockwise.**

Q. 12. The motion of copper plate is damped when it is allowed to oscillate between the two poles of a magnet. What is the cause of this damping? *[CBSE (AI) 2013]*

Ans. As the plate oscillate, the changing magnetic flux through the plate produces a strong eddy current in the direction, which opposes the cause.

Also, copper being diamagnetic substance, it gets magnetised in the opposite direction, so the plate motion gets damped.