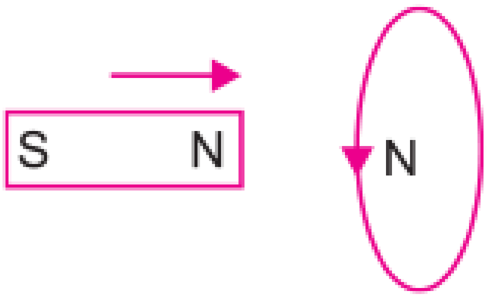
Short Answer Questions – I (PYQ)

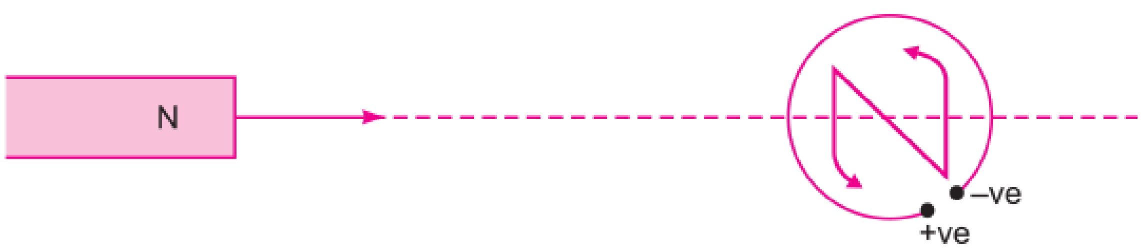
Q. 1. State Lenz's Law.

A metallic rod held horizontally along east-west direction, is allowed to fall under gravity. Will there be an emf induced at its ends? Justify your answer.
[CBSE Delhi 2013]

Ans. Lenz's law: According to this law "the direction of induced current in a closed circuit is always such as to oppose the cause that produces it."



The direction of induced current in a circuit is such that it opposes the very cause which generates it. Yes, an emf will be induced at its ends. Justification: As the metallic rod falls down, the magnetic flux due to vertical component of Earth's magnetic field keeps on changing.



Q. 2. When a bar magnet is pushed towards (or away) from the coil connected to a galvanometer, the pointer in the galvanometer deflects. Identify the phenomenon causing this deflection and write the factors on which the amount and direction of the deflection depends. State the laws describing this phenomenon.

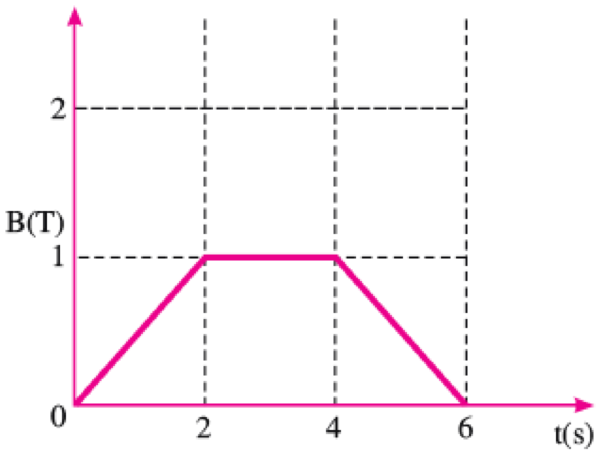
Ans. The phenomenon involved is electromagnetic induction (EMI). For the deflection amount depends upon the speed of movement of the magnet or rate of change of flux. Direction depends on the sense (towards, or away) of the movement of the magnet. Direction of deflection is according to Lenz' law.

The law describing the phenomenon is:

The magnitude of the induced emf, in a circuit, is equal to the rate of change of the magnetic flux through the circuit.

$$\varepsilon = -\frac{d\varphi_B}{\text{dt}}$$

Q. 3. The magnetic field through a circular loop of wire 12 cm in radius and 8.5 Ω resistance, changes with time as shown in the figure. The magnetic field is perpendicular to the plane of the loop. Calculate the induced current in the loop and plot it as a function of time. [CBSE (F) 2017]



Ans. We know,

$$\varepsilon = \frac{-d\varphi}{\text{dt}} = \frac{-d(\text{BA})}{\text{dt}} = A\frac{\text{dB}}{\text{dt}}$$

$$I = \frac{\varepsilon}{R} = \frac{-A\left(\frac{\text{dB}}{\text{dt}}\right)}{R}$$

For 0< t< 2

$$= \frac{-3.14(0.12)^2 ? 1}{2 ? 8.5} = 0.0026\ A$$

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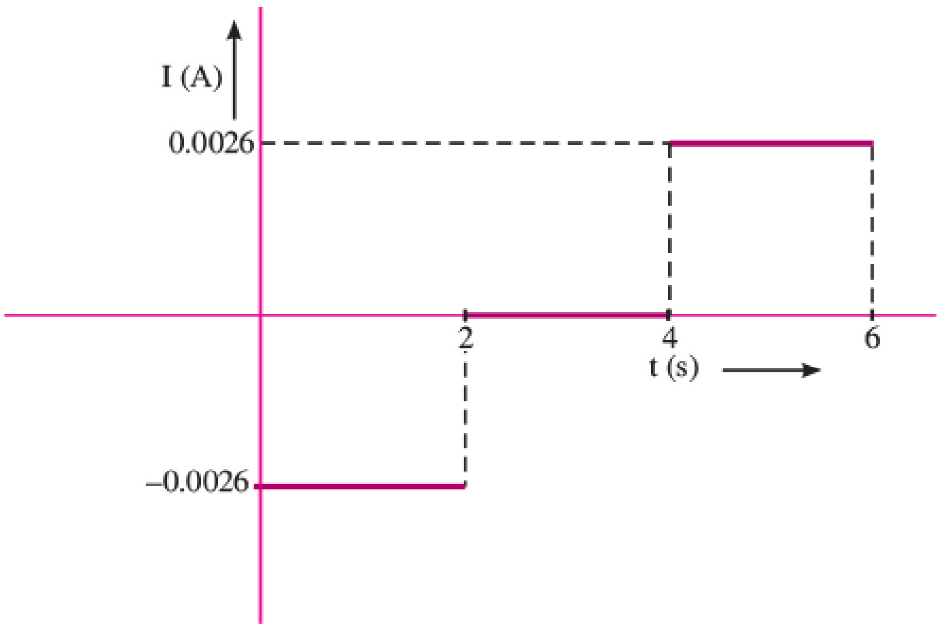
For, 2 < t < 4

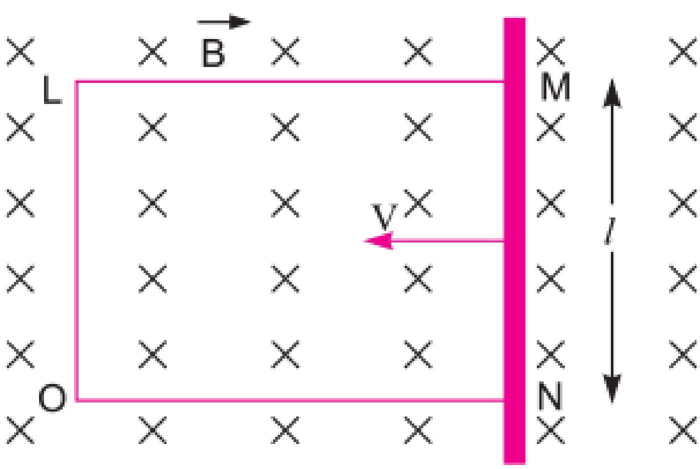
$\frac{dB}{dt} = 0 \Rightarrow I = 0$

For, $4 < t < 6$

$I = +0.0026$



Q. 4. A rectangular conductor LMNO is placed in a uniform magnetic field of 0.5 T. The field is directed perpendicular to the plane of the conductor. When the arm MN of length of 20 cm is moved towards left with a velocity of 10 ms^{-1}, calculate the emf induced in the arm. Given the resistance of the arm to be 5Ω (assuming that other arms are of negligible resistance), find the value of the current in the arm.
[CBSE (AI) 2013]



Ans. Induced emf in a moving rod in a magnetic field is given by

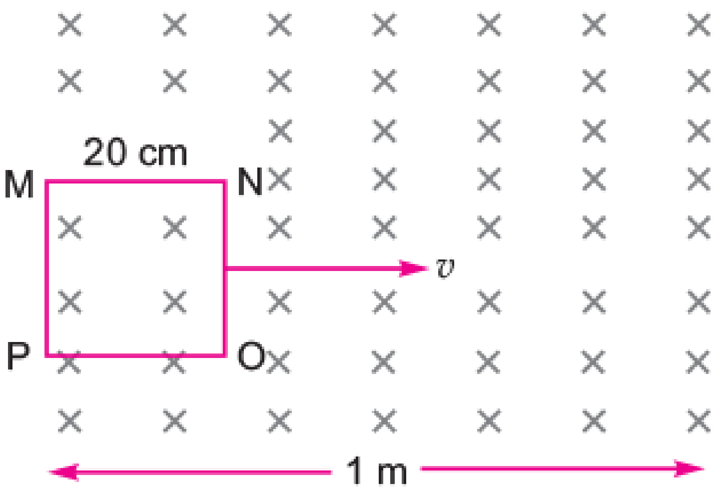
ε = – Blv

Since the rod is moving to the left so

ε = + Blv = 0.5 × 0.2 × 10 = 1 V

Current in the rod $I = \frac{\varepsilon}{R} = \frac{1}{5} = 0.2A$

Q. 5. A square loop MNOP of side 20 cm is placed horizontally in a uniform magnetic field acting vertically downwards as shown in the figure. The loop is pulled with a constant velocity of 20 cms^{-1} till it goes out of the field.



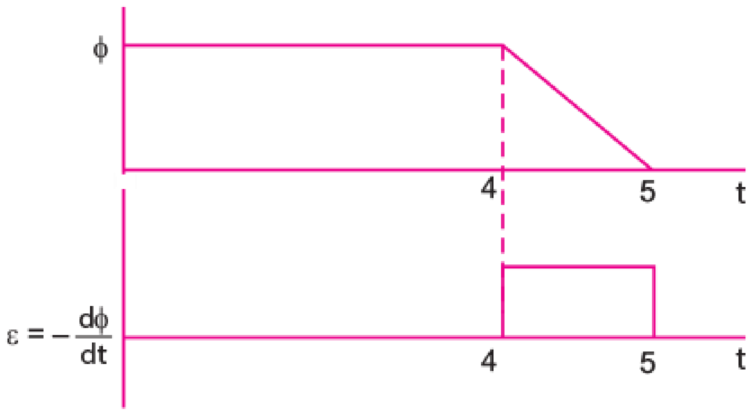
(i) Depict the direction of the induced current in the loop as it goes out of the field. For how long would the current in the loop persist?

(ii) Plot a graph showing the variation of magnetic flux and induced emf as a function of time. [CBSE Panchkula 2015]

Ans. (i) $t = \frac{d}{v} = \frac{20}{20} = 1s$

Induced current will last for 1 second till the length 20 cm moves out of the field.

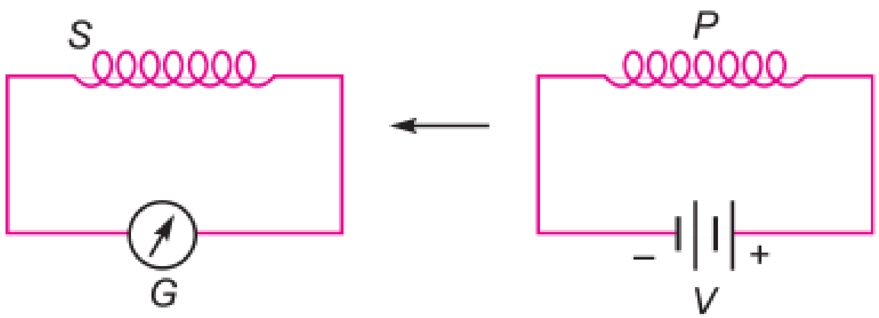
(ii)



Q. 6. (i) When primary coil P is moved towards secondary coil S (as shown in the figure below) the galvanometer shows momentary deflection.

What can be done to have larger deflection in the galvanometer with the same battery?

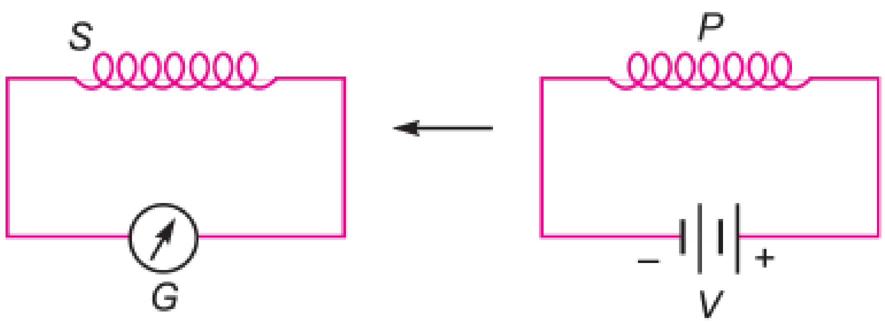
(ii) State the related law. [CBSE Delhi 2010]



Ans. (i) For larger deflection, coil P should be moved at a **faster rate.**

(ii) Faraday law: The induced emf is directly proportional to rate of change of magnetic flux linked with the circuit.

Q. 7. A current is induced in coil C1 due to the motion of current carrying coil C_2.



(i) Write any two ways by which a large deflection can be obtained in the galvanometer G.

(ii) Suggest an alternative device to demonstrate the induced current in place of a galvanometer. [CBSE Delhi 2011]

Ans. (1) The deflection in galvanometer may be made large by

(i) Moving coil C_2 towards C_1 with high speed.

(ii) By placing a soft iron laminated core at the centre of coil C_1.

(2) The induced current can be demonstrated by connecting a torch bulb (in place of galvanometer) in Coil C_1. Due to induced current the bulb begins to glow.

Q. 8. Answer the following questions

(i) Define mutual inductance.

(ii) A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s, what is the change of flux linkage with the other coil?
[CBSE Delhi 2016]

Ans. Change of flux for small change in current

$$d\varphi = \text{MdI} = 1.5\ (20 - 0)\ \text{weber} = 30\ \text{weber}$$

Q. 9. A long solenoid with 15 turns per cm has a small loop of area 2.0 ^{cm2} placed inside the solenoid normal to its axis. If the current carried by the solenoid changes steadily from 2.0 A to 4.0 A in 0.1 s, what is the induced emf in the loop while the current is changing? [CBSE (F) 2016]

Ans.

Mutual inductance of solenoid coil system

$$M = \frac{\mu_0 N_1 N_2 A_2}{l}$$

Here $N_1 = 15$, $N_2 = 1$, $l = 1$ cm $= 10^{-2}$ m, $A_2 = 2.0$ cm^2 $= 2.0\times10^{-4}$ m^2

$$\therefore \quad M = \frac{4\pi\times10^{-7}\times15\times1\times2.0\times10^{-4}}{10^{-2}} = 120\pi\times10^{-9}H$$

Induced emf, in the loop

$$\varepsilon_2 = M\frac{\Delta I}{\Delta t} \text{ (numerically)}$$

$$= 120\pi \times10-9 \ \frac{(4-2)}{0.1}$$

$$= 120\times3.14\times10^{-9}\times \frac{2}{0.1} = 7.5\times10^{-6}\text{ V} = 7.5\ \mu\text{V}$$

Q. 10. A toroidal solenoid with air core has an average radius of 15 cm, area of cross-section 12 cm^2 and has 1200 turns. Calculate the self-inductance of the toroid. Assume the field to be uniform across the cross-section of the toroid. [CBSE (F) 2014]

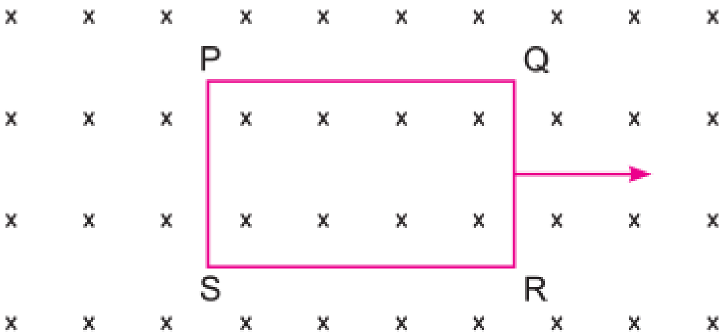
Ans.

Here, $r = 15$cm $= 0.15$ m, A= 12 cm^2 $= 12\times10^{-4}$ m^2 and $N = 1200$

$$\text{Self inductance, } L = \frac{\mu_0 N^2 A}{l} = \frac{\mu_0 N^2 A}{2\pi r}$$

$$= \frac{4\pi\times10^{-7}\times(1200)^2\times12\times10^{-4}}{2\pi\times0.15} = 2.3\times10^{-3}H.$$

Q. 11. The closed loop (PQRS) of wire is moved out of a uniform magnetic field at right angles to the plane of the paper as shown in the figure. Predict the direction of the induced current in the loop. [CBSE (F) 2012]

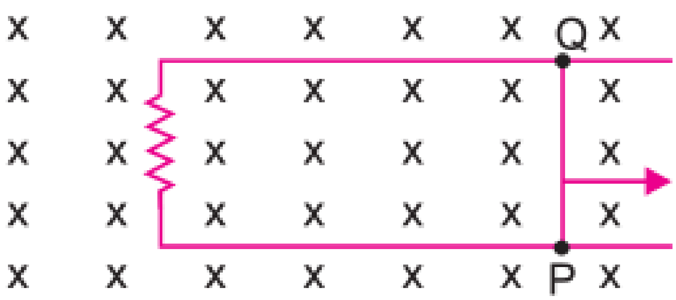


Ans. So far the loop remains in the magnetic field, there is no change in magnetic flux linked with the loop and so no current will be induced in it, but when the loop comes out of the magnetic field, the flux linked with it will decrease and so the current will be induced so as to oppose the decrease in magnetic flux, i.e., it will cause magnetic field downwards; so the direction of current will be clockwise.

Short Answer Questions – I (OIQ)

Q. 1. A 0.5 m long metal rod PQ completes the circuit as shown in the figure. The area of the circuit is perpendicular to the magnetic field of flux density 0.15 T. If the resistance of the total circuit is 3Ω calculate the force needed to move the rod in the direction as indicated with a constant speed of 2ms^{-1}.

Ans. Given: $l = 0.5m$, $B = 0.15T$, $R = 3\Omega$, $v = 2\ ms^{-1}$



emf., $\varepsilon = vBl$

Current, $I = \frac{\varepsilon}{R} \Rightarrow \frac{vBl}{R}$

Force needed to move the rod,

$$F = BIl = B \times \frac{vBl}{R} \times l = \frac{vB^2 l^2}{R}$$

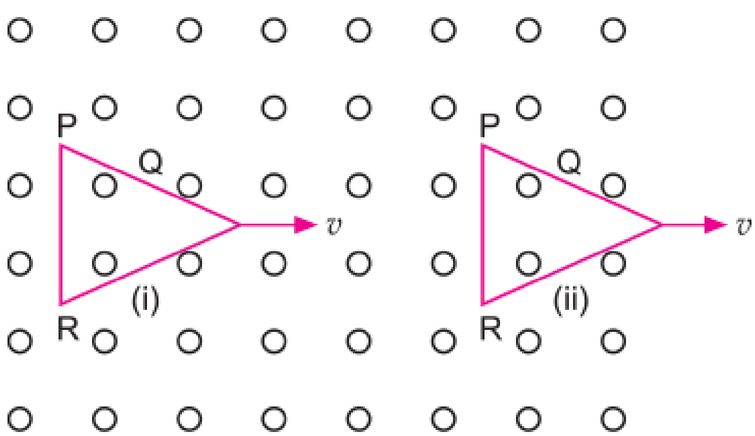
$$= \frac{2 \times (0.15)^2 \times (0.5)^2}{3} = 3.75 \times 10^{-3} N$$

Q. 2. If the self-inductance of an iron core inductor increases from 0·01 mH to 10 mH on introducing the iron core into it, what is the relative permeability of the core material used?

Ans.

$$\text{Relative permeability } \mu_r = \frac{L_{\text{medium}}}{L_{\text{air}}} = \frac{10 \text{ mH}}{0.01 \text{ mH}} = 100$$

Q. 3. Fig. shows two positions of a loop PQR in a perpendicular uniform magnetic field. In which position of the coil is there an induced emf?

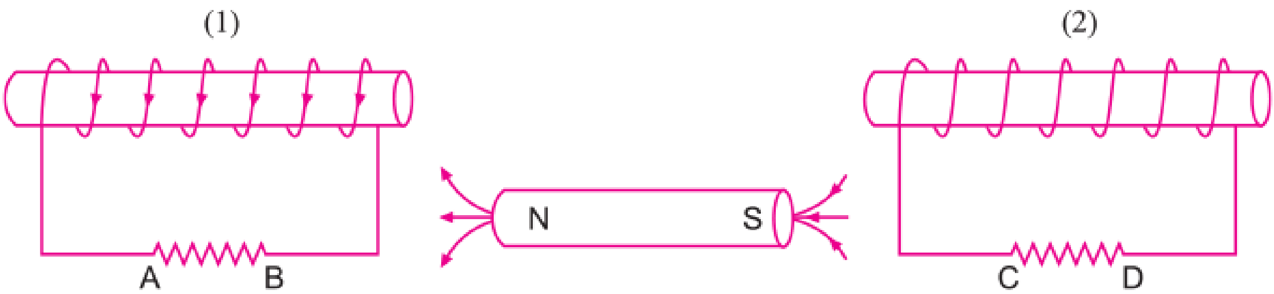


Ans. In position (i), the coil remains as such in magnetic field, so there is no magnetic flux change in the coil, hence no emf is induced.

In position (ii) the coil is coming out of the magnetic field, so the magnetic flux linked with it decreases and so an emf is induced in the coil.

Q. 4. In the figure given below, a bar magnet moving towards the right or left induces an emf in the coils (1) and (2). Find, giving reason, the directions of the

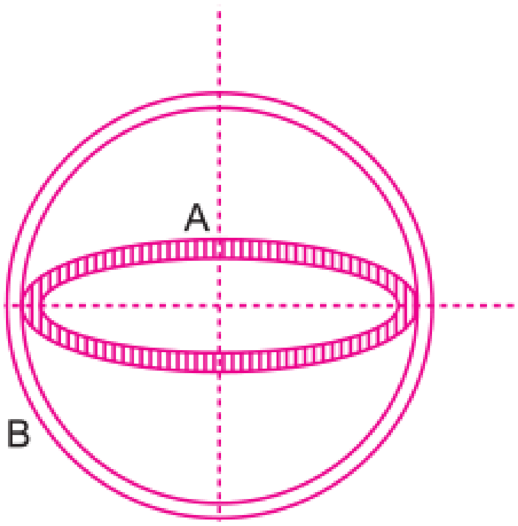
induced currents through the resistors AB and CD when the magnet is moving (a) towards the right, and (b) towards the left.



Ans. (a) When magnet moves towards the right, the nearer faces of coils, 1 and 2 act as south poles, so current induced in AB is from B to A and in coil 2 from C to D.

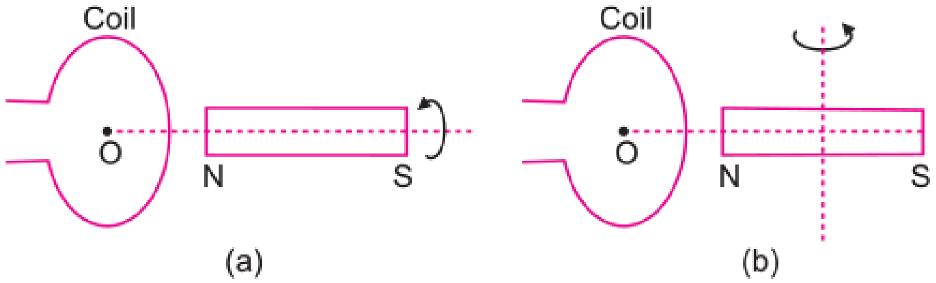
(b) When magnet moves towards left, the nearer faces of coils act as north poles, so current induced in coil, 1 will be from A to B and in coil 2 from D to C.

Q. 5. Two coils of wire A and B are placed mutually perpendicular as shown in figure. When current is changed in any one coil, will the current induce in another coil?



Ans. No; this is because the magnetic field due to current in coil (A or B) will be parallel to the plane of the other coil (A or B) Hence, the magnetic flux linked with the other coil will be zero and so no current will be induced in it.

Q. 6. A cylindrical bar magnet is kept along the axis of a circular coil and near it as shown in fig. Will there be any induced emf at the terminals of the coil, when the magnet is rotated



(i) About its own axis and

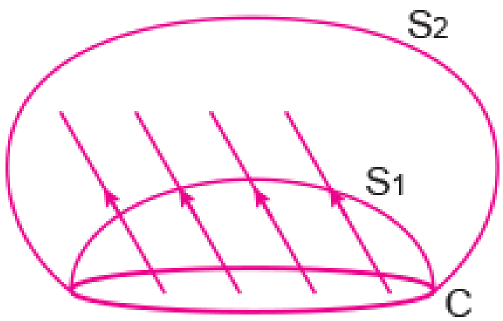
(ii) About an axis perpendicular to the length of the magnet?

Ans. (i) When the magnet is rotated about its own axis, then due to symmetry of magnet the magnetic flux linked with circular coil remains unchanged, hence no emf is induced at terminals of coil.

(ii) When the magnet is rotated about an axis perpendicular to the length, the positions of *N* and *S* poles of magnet changes continuously; so the magnetic flux linked with the coil changes continuously; hence the emf is induced at the terminals of the coil.

Q. 7. Consider a closed loop C in a magnetic field (see figure). The flux passing through the loop is defined by choosing a surface whose edge coincides with the loop and using the formula $\varphi = \overrightarrow{B_1}.d\overrightarrow{A_1} + \overrightarrow{B_2}.d\overrightarrow{A_2} + .$

Now if we chose two different surfaces S_1 and S_2 having C as their edge, would we get the same answer for flux. Justify your answer. [NCERT Exemplar]



Ans. One gets the same answer for flux. Flux can be thought of as the number of magnetic field lines passing through the surface (We draw dN = BA lines in a area ΔA perpendicular to B). As field lines of B cannot end or start in space (they form closed loops) number of lines passing through surface S_1 must be the same as the number of lines passing through the surface S_2.