Chapter 6

Electromagnetic Induction

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BOARD:- 2013

1. Write faraday's Law of electromagnetic induction. [1 MARK]

⇒ (A) Faraday's 1st Law - whenever a flux linked with any coil or circuit changes w.r.t time then emf induces in it.

(B) Faraday's 2nd Law - Rate of change in magnetic flux is directly proportional to the magnitude of induced e.m.f.

$$|e| \propto \frac{d\phi}{dt}$$

2. Draw a labelled diagram of AC generator and describe it. Derive an expression for instantaneous value of induced emf. [1+3=4]

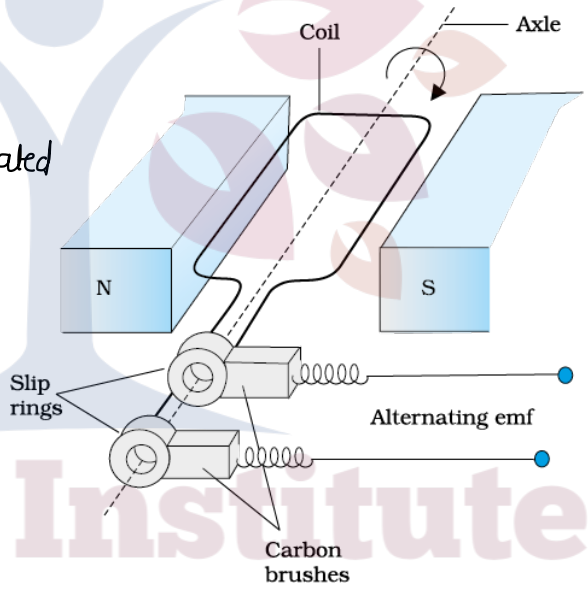
⇒ (A) Labelled diagram of AC Generator - The major parts are-
(i) field magnet (ii) Armature (iii) Slip rings (iv) Brushes.

(i) Field Magnet - Generate a strong magnetic field by horse shoe magnets N & S.

(ii) Armature - Rectangular coil ABCD having many turns of insulated copper wire wrapped on soft iron.

(iii) Slip Rings - S_1 & S_2
- These rotates along with armature.

(iv) Brushes - Made up of carbon.
- This slip remains in touch with these brushes.



Induced EMF - According to faraday Law -

$$e = -\frac{d\phi}{dt} \quad -(1)$$

$$\phi = \vec{B}\cdot\vec{A} = BA\cos\theta \qquad \left\{\omega = \frac{\theta}{t}\right\}$$

$$\phi = BA\cos\omega t$$

Put in eqn (1)

$$e = \frac{-d(BA\cos\omega t)}{dt}$$

$$e = \frac{-BA\, d(\cos\omega t)}{dt}$$

$e = -BA(-\omega \sin\omega t)$

$e = BA\omega \sin\omega t$

for N number of turns -

$$\boxed{e = BA\omega N \sin\omega t}$$

Here $e_0 = BA\omega N$
↳ max. induced emf

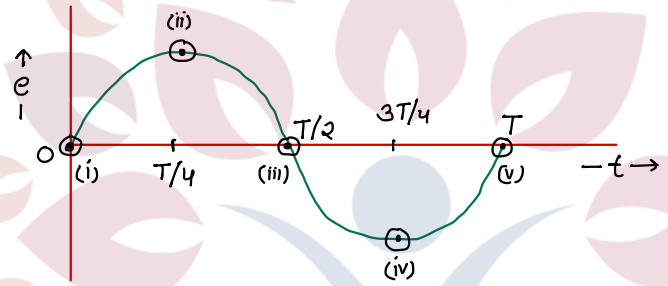
$$\boxed{e = e_0 \sin\omega t} \quad \text{or} \quad V = V_0 \sin\omega t$$

Induced Current (I) ⇒ $I = V/R$

$$I = \frac{V_0 \sin\omega t}{R}$$

$$\boxed{I = I_0 \sin\omega t}$$

Graph b/w induced emf (e) & t



(i) $t = 0$ $\quad e = e_0 \sin\omega t = e_0 \sin\left(\frac{2\pi}{T}\right) \times 0 = 0$

(ii) $t = T/4$ $\quad e = e_0 \sin\frac{2\pi}{T} \times \frac{T}{4} = e_0 \sin\pi/2 = e_0$

(iii) $t = T/2$ $\quad e = e_0 \sin\frac{2\pi}{T} \times \frac{T}{2} = e_0 \sin\pi = 0$

(iv) $t = 3T/4$ $\quad e = e_0 \sin\frac{2\pi}{T} \times \frac{3T}{4} = e_0 \sin\frac{3\pi}{2} = -e_0$

(v) $t = T$ $\quad e = e_0 \sin\frac{2\pi}{T} \times T = e_0 \sin 0 = 0$

BOARD:- 2013 (Supp.)

3. (i) what happens when a piece of metal is placed in a variable magnetic field?
(ii) write the name of two factors on which inductance depends.

⇒ [1 + 1/2 + 1/2 = 2]

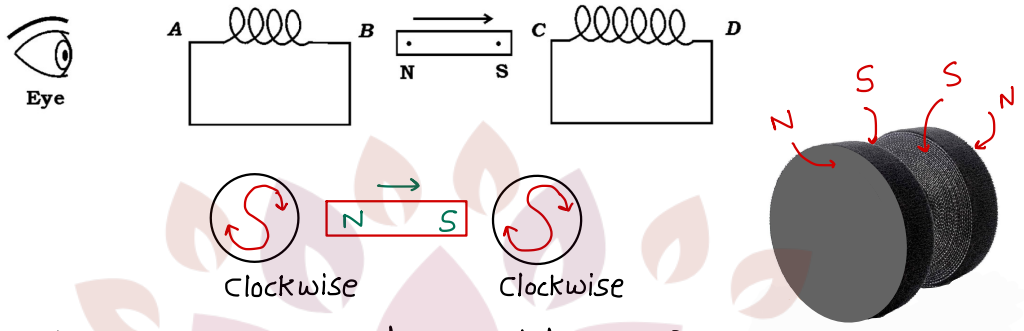
(i) emf is induced and current is generated.
(Eddy Current is generated)

(ii) $L = \frac{\mu_0 N^2 \pi R}{2}$

ⓐ Number of Turns
ⓑ Radius of coil
ⓒ Medium

BOARD:- 2014

4. A bar magnet NS is moved in the direction indicated by an arrow b/w two coils AB and CD as shown in figure. In which coil the direction of current will look like anti-clockwise if viewed from left side?

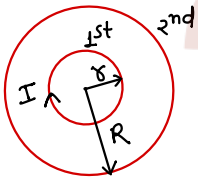


⇒

→ Anticlockwise in AB if viewed from Left side.

5. Two concentric circular coils of radii r and R are placed coaxially with centre coinciding. If R>>r then calculate the mutual inductance b/w the coil.

⇒



Let two concentric circular coils of radius r & R be placed coaxially with centre coincide.

- Magnetic field due current carrying inner coil- $B_1 = \frac{\mu_0 N I_1}{2r} = \frac{\mu_0 I_1}{2r}$

- Flux linked with 2nd loop

$\phi_2 = B_1 A_2$

put value

$\phi_2 = \frac{\mu_0 I_1}{2r} (\pi R^2)$

- Mutual inductance

$M = \frac{\phi_2}{I_1}$

$M = \frac{\mu_0 I_1 (\pi R^2)}{2r \times I_1}$

$M = \frac{\mu_0 \pi R^2}{2r}$

BOARD:- 2015

6. write the statement of Lenz's Law of electromagnetic induction.
A 2m horizontal long straight conducting wire extending from east to west direction is falling with a speed of 5 m/s ⊥ to the horizontal component of earth's magnetic field 0.3×10^{-4} tesla. Calculate instantaneous emf induced across the ends of wire.

⇒ (i) Lenz's Law - The direction of the induced current in circuit such that

it oppose the cause which produces it.

$$e = -\frac{d\phi}{dt}$$

(ii) $l = 2m$, $V = 5\ m/s$, $B = 0.3 \times 10^{-4}\ T$

$E = BlV$

$E = 0.3 \times 10^{-4} \times 2 \times 5 = 3 \times 10^{-4}$ volts.

BOARD:- 2016

7. Write faraday's Law of electromagnetic induction. [1]

8. Current in a circuit falls from 5A to zero in 0.1 s. If an average emf of 100 volt is induced then calculate self-inductance of a inductor in the circuit. [2 MARKS]

⇒

$$E = -L\, dI/dt$$

$$L = -E / dI/dt = \frac{-100 \times 0.1}{-5}$$

$L = 2$ henry.

BOARD:- 2017

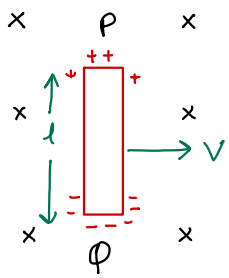
8. Why self induction is called inertia of electricity? [1]

⇒ The electromotive force generated by self-induction oppose every change in current in the circuit. The same function is performed by mass in mechanics, which is the measure of inertia of a body. So, self-inductance is a measure of electrical inertia.

9. A conducting rod of length 'l' is moving with constant linear speed 'v' in a uniform magnetic field 'B'. This arrangement is mutually ⊥. Obtain the expression of motional electromotive force. [2 MARKS]

⇒ emf induced in conductor due to motion of conductor in magnetic field is called Motional emf.

→ Let we have a rod of length 'l' which is moving in magnetic field 'B' with velocity V. ($V \perp B$)



Magnetic force on conducting rod -

$$\vec{F_m} = q(\vec{V} \times \vec{B})$$

$\theta = 90°$

$F_m = qVB$ — ①

(direction Q to P)

→ This force acts on free e^- of rod. Electron being negative charge feels force in P to Q direction. Due to which

P ⇒ Become +ve (due to deficit of e^-)

Q ⇒ Become -ve (due to excess of e^-)

→ Due to it a potential difference generated. Due to which electric force applied on e⁻ in P to Q direction.

$$F_e = qE \quad -(2)$$

→ when both the force become equal -

$$qVB = qE$$

$$\boxed{E = VB}$$

Induced emf ⇒ $e = El$

$$\boxed{e = VBl}$$

BOARD - 2018

10. The length of side of a square loop is 4m. This loop is placed in an uniform magnetic field of 2.5T. outside the loop, the magnetic field is zero and it is coming out side from magnetic field ⊥ with velocity 2m/s. find the value of induced emf in loop after one second. [2Marks]

⇒

$$e = (B_1 - B_2)lv$$

$$e = (2.5 - 0)4 \times 2$$

$$e = 20 \text{ volt}$$

BOARD - 2018 (Supp.)

11. Write Dimensional formula for coefficient of mutual induction. [1]

⇒ $[ML^2T^{-2}A^{-2}]$

BOARD - 2019

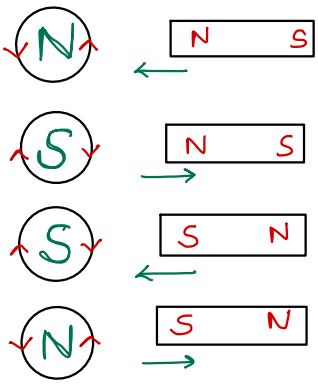
13. Write Lenz's Law. Lenz's Law obey's Law of conservation of Energy.

⇒

$$e = -\frac{d\phi}{dt}$$

The direction of the induced current in circuit such that it oppose the cause which produces it.

Explanation -



Lenz's Law states that induced current always opposes the cause. This means that when electric energy is produced, some other force must be doing work that is converted into electrical energy.

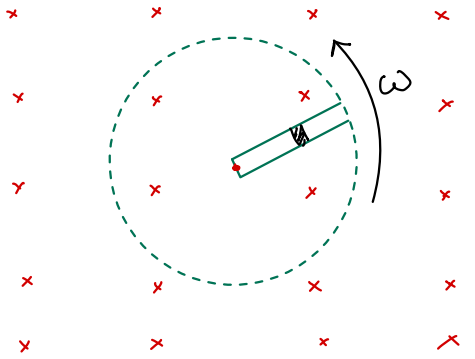
(i), (iii) work against force of repulsion

(ii), (iv) work against force of attraction

→ These work converted into electric energy

→ Hence Lenz law follow Law of conservation of energy.

14. Derive an expression for induced emf in rod rotating in a uniform magnetic field. Draw necessary diagram.



Let we have rod of length 'l'. Angular velocity (ω) and rod is rotating in uniform magnetic field (B).

Induced emf in elementary length of rod -

$$de = BVdl$$

$$\int de = \int_0^l BVdl$$

$$e = B\int_0^l Vdl$$

Relation b/w linear velocity and angular velocity

$$V = x\omega$$

$$V = l\omega$$

$$e = B\int_0^l l\omega dl$$

$$e = B\omega\int_0^l l\,dl$$

$$e = B\omega\left[l^2/2\right]_0^l$$

$$e = B\omega\left[\frac{l^2}{2} - 0\right]$$

$$\boxed{e = \frac{1}{2}B\omega l^2}$$

$$\omega = \frac{\theta}{t} = \frac{2\pi}{T} \text{ or } 2\pi f$$

$$e = \frac{1}{2}B(2\pi f)l^2$$

$$e = B(\pi l^2)f$$

$$\boxed{e = BAf}$$

BOARD:- 2020

15. Obtain an expression for the induced emf $e = e_0 \sin\omega t$ due to the rotational motion of the rectangular coil in the uniform magnetic field. Draw a graph b/w induced emf 'e' and time 't'.

BOARD:- 2020 (Supp.)

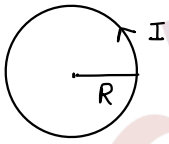
16. Write the definition of self inductance. Derive an expression of the self inductance of plane circular coil. [1+2=3]

⇒ When flux linked with any coil or circuit changes then an emf induces in it. This process is called self-induction.

$$\phi \propto I$$
$$\phi = LI$$
$$\boxed{L = \phi/I}$$

L = Coefficient of self inductance
SI unit ⇒ Wb/A or Henery (H)

Self induction of plane circular coil -



Let we have a current carrying coil of radius (R). self-inductance of coil is L and no. of turns in coil is N.

→ Let flux linked with one turn of coil is ϕ

$$\phi = BA$$

if N turns then

$$\phi = BNA$$

→ By definition of self inductance -

$$\phi = LI$$

$$LI = BNA$$
$$L = \frac{BNA}{I}$$
$$L = \frac{\mu_0 NI}{2R} \times \frac{N \times \pi R^2}{I}$$
$$\boxed{L = \mu_0 \frac{N^2 \pi R}{2}}$$

BOARD:- 2021

17. On conservation of which quantity the Lenz's Law is based?

⇒ Energy conservation.

18. Derive an expression for induced emf in rod rotating in a uniform magnetic field. Draw necessary diagram.

BOARD:- 2022

19. The ratio of flux linkage ($N\phi$) associated with a coil having N turns to the current (I) flowing through it ($N\phi/I$) is _____.

⇒ Self inductance.

20. Write faraday's Law of magnetic induction.

21. $e = Blv$ derivation.

BOARD:- 2023

22. Current in a circuit falls from 5A to 1A in 0.1s. If an average emf of 200V induced. Give an estimate of the self inductance of circuit.

⇒ $e = -L\, dI/dt$

$L = -e/dI/dt$

$L = \dfrac{-200}{\frac{(1-5)}{0.1}}$

$L = \dfrac{-200 \times 0.1}{-4}$

$L = 5H$

23. Write Statement of (i) Faraday's Law (ii) Lenz's Law

BOARD:- 2024

24. The device is based on the principle of mutual induction is- 1/2

a. AC generator b. Galvanometer

c. Voltmeter d. Transformer

Answer - Transformer

25. Why self-inductance is called electrical inertia? 1

26. Draw Clear & Labelled diagram of AC generator. 1 1/2

27. A 5m long straight horizontal conducting wire situated in the east to west direction is falling with a speed of 2 m/s ⊥ to the horizontal component of the earth magnetic field of 0.3×10^{-4} T. Find the instantaneous value of emf induced b/w the ends of the wire 1 1/2

⇒ $l = 5m$

$B = 0.3 \times 10^{-4}$

$V = 2 m/s$

$e = BlV \sin\theta$

$e = (0.3 \times 10^{-4})(5)(2)\sin 90^\circ$

$e = 3 \times 10^{-4}$ volt