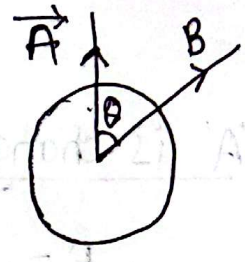
Hard steel →
- Coercivity is high.
- Retentivity is low.
- susceptibility is low.
- permeability is low

Used → permanent magnet बनाने में

Electromagnetic Induction



Magnetic Flux:-

$$\phi = \vec{B} \cdot \vec{A}$$

$$= BA\cos\theta$$

(A → Area.)

where, θ ⇒ angle made by $\vec{B}$ with the normal of surface area.

→ If θ = 0°, $\phi = BA$ (maximum)

The lines of force are passing normal to the surface area or parallel to the normal of surface area.

→ If θ = 90°, $\phi = 0$

- unit of ϕ is weber (in SI)
  Maxwell (in CGS)

$\therefore$ 1 Wb = 10^8 Maxwell

1 T = 10^4 guass

$\phi = B \times A$

$= 10^4 \times 10^4 = 10^8$

Faraday's law of EMI

→ Change in flux induces emf.

→ magnitude of induced emf is directly proportional to the rate of change of flux i.e. $\mathcal{E} \propto \frac{d\phi}{dt}$

$$\boxed{\mathcal{E} = -\frac{d\phi}{dt}}$$ ⇒ -ve sign indicates that the induced emf opposes the cause producing it.

$\because \phi = N B A \cos\theta$ (N = no. of coils)

B is acting ⊥r to plane of coil → ($\theta = 0°$)

$$\boxed{\mathcal{E} = -\frac{d\,NBA\cos\theta}{dt}}$$

If B is changing,

$$\mathcal{E} = -NA\cos\theta \frac{dB}{dt}$$

If 'A' is changing,

$$\mathcal{E} = -NB\cos\theta \frac{dA}{dt}$$

If θ is changing. ∵ ($\theta = \omega t$)

$$\mathcal{E} = -NBA \frac{d\cos\omega t}{dt}$$

$$= -NBA(-\omega \sin\omega t)$$

$$\boxed{\mathcal{E} = NBA\omega \sin\omega t}$$

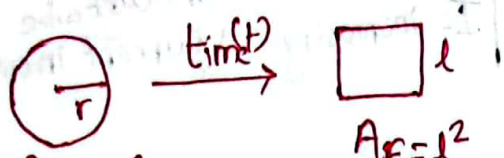
- Induced emf depends upon:-

① A ② B ③ θ ④ The relative motion between bar magnet & coil.

but does not upon the resistance of the coil.

Q. The magnetic lines of force are acting perpendicular to the plane of a circular coil having magnitude of field B. If the coil is converted into the square in time t. Find the induced emf? (If radius of coil is r).

$(\theta = 0^\circ)$

→ 

$A_i = \pi r^2$

$\because 2\pi r = 4l$

$l = \frac{\pi r}{2}$

$A_F = l^2$

$= \left(\frac{\pi r}{2}\right)^2$

$= \frac{\pi^2 r^2}{4}$

$$E = \frac{d\phi}{dt}$$

$$= \frac{-(\phi_2 - \phi_i)}{t}$$

$$= \frac{-B(A_F - A_i)}{t}$$

$$= \frac{-B\left(\frac{\pi^2 r^2}{4} - \pi r^2\right)}{t}$$

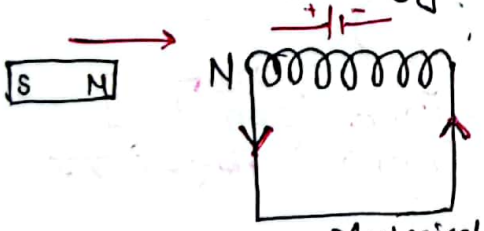
$$\boxed{E = \frac{B(4\pi r^2 - \pi^2 r^2)}{4t}}$$

Lenz's law

→ induced emf opposes the cause producing it.

→ conservation of energy.

बढ़नेलाई बढ़न नदिन ओर तिर तान्ने।
घट्नेलाई घट्न नदिन त्यसैतिर धकेल्ने

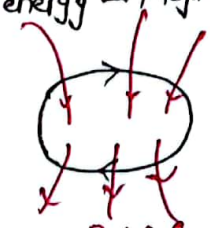


current → anticlockwise

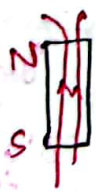
• Mechanical energy → electrical energy → Magnetic energy → Mechanical energy



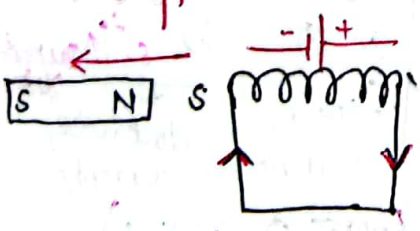
anticlockwise



Clockwise







current → clockwise

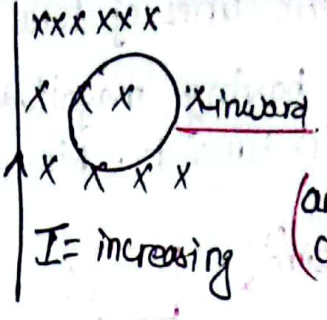
→ Coil को भित्र तिर increasing field lagyo

⇓

induced field बाहिर तिर लाग्नु पर्‍यो (घट्नेलाई घटन नदिन)

⇓

(anticlockwise current)



(anticlockwise current in coil)

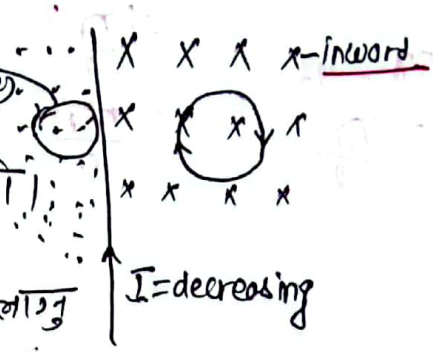
→ current carrying conductor ले right तिर Inward decreasing field लाग्यो।

⇓

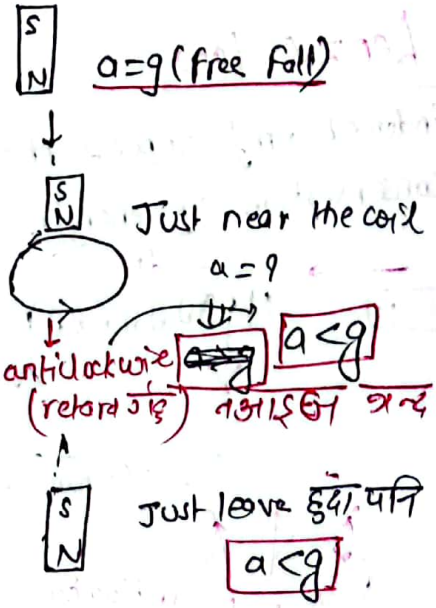
So, induced field पनि भित्र तिर लाग्नु पर्‍यो (घटनेलाई घटन नदिन)

⇓

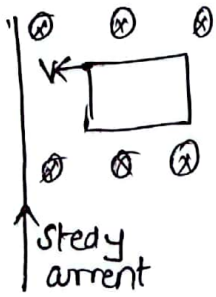
(clockwise current)



~~current carrying conductor ले~~

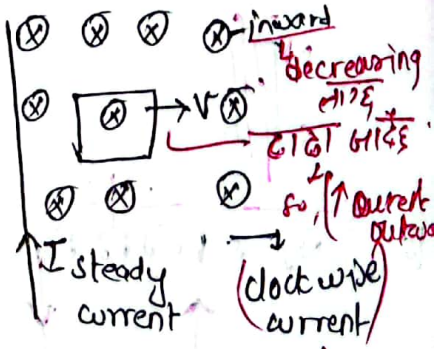


→



(anticlockwise)

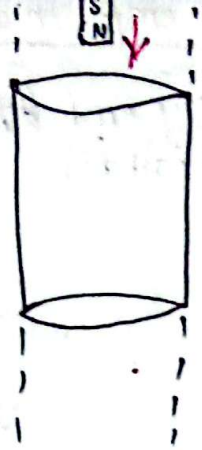
(बाहिर ↓ लाग्छ भित्र ↑ लाग्छ)



(बाहिर ↑, भित्र ↓)

Long cylindrical copper tube

→ It gains the terminal velocity. (accleration = 0)

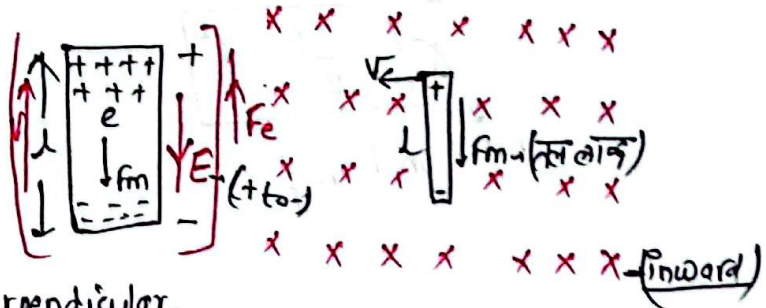


Motional emf.

. B-acting inward. (z-axis)

. l → y-axis मा छ

. v → x-axis मा



→ B, l & v are mutually perpendicular.

At equilibrium, $F_e = F_m$

$$qE = BqV$$

$$\cancel{q}\frac{V}{L} = B\cancel{q}v$$

$$\boxed{E = \frac{V}{L}}$$ motional emf

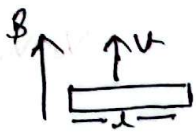
Motional emf → $\boxed{V = BLv}$ ← velocity

B → magnetic field

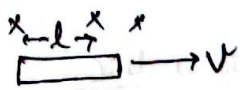
L → length of conductor

For no motional emf:-

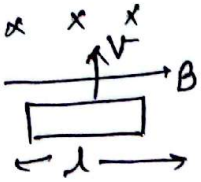
① $v \parallel B \rightarrow V = 0$



② $v \parallel L \longrightarrow V = 0$



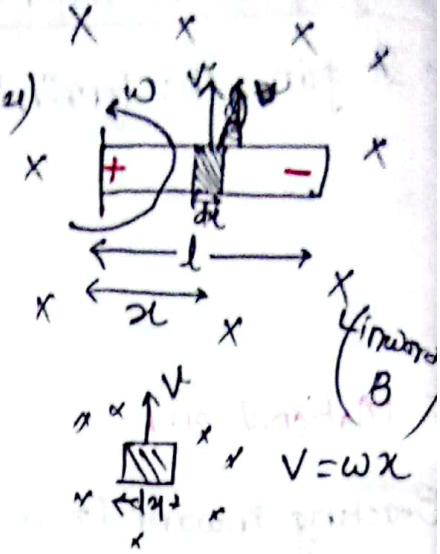
③ $B \parallel L \longrightarrow V = 0$



तिन मध्यै कुनै पनि parallel छ भने $V = 0$

Induced emf in a rotating rod:-

- Elementary emf (small part को) $d(V) = B\,dx\,V$ $(l = dx)$



$$= B\,dx\,\omega x$$

$$\int_0^l dV = \int_0^l B\omega x\,dx$$

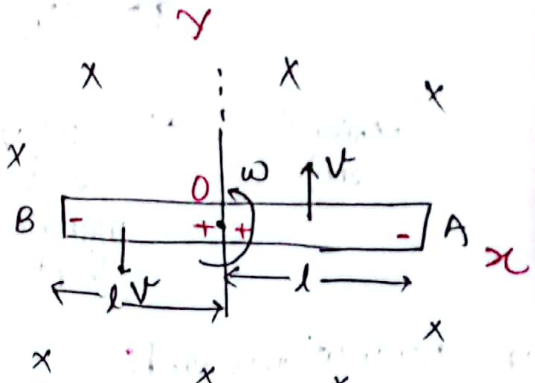
$$V = B\omega\left(\frac{x^2}{2}\right)_0^l$$

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

rotational emf

Right hand rule बाट velocity माथि, B → भित्र र Palm ले +ve terminal shoe गर्दै। So, (+ - - -)

→

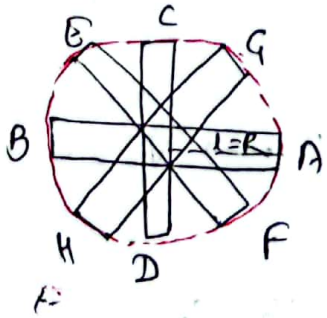


so, $\boxed{V_A - V_B = 0}$

$\boxed{V_A = V_B}$

$$V_0 - V_B = \frac{Bl^2\omega}{2} \qquad V_0 - V_A = \frac{Bl^2\omega}{2}$$

Rotational emf for a disc



$$\boxed{V = \frac{BR^2\omega}{2}}$$

(emf)

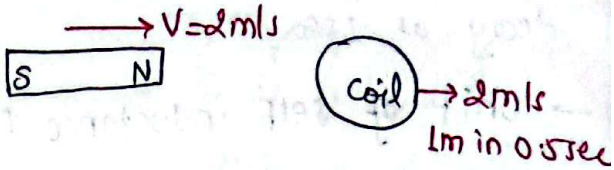
$$V = \frac{BR^2\,\cancel{2}\pi F}{\cancel{2}}$$

$$V = B\pi R^2 F = BAF$$

Area

$\therefore \boxed{V = BAF}$

Q. →



bar magnet is moved 2m in 1sec & coil is moved 1m in 0.5sec in same direction. Find the induced emf in the coil?

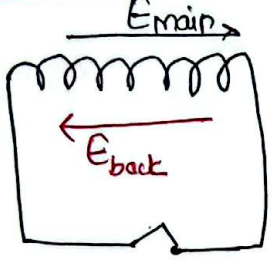
Solu:

velocity of bar mag & coil are same. So, no induced emf.

(induced emf = 0)

↳ relative motion = 0.

#Self inductance

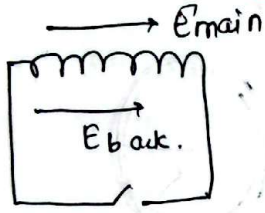


Switch on मा

→ current peak हुन 3 sec लाग्थ्यो अनै due to back emf ले गर्दा peak पुग्ने Time लाई बढायो (Delay गरायो)

switch on → current grows

↓ opposes



Switch off मा

→ current decay → supports

↳ current decay हुन अहिले zero मानौं 3 sec लाग्थ्यो अनै due to back emf ले गर्दा peak ~~पुग्ने Time~~ बढायो (~~fast~~ delay गरायो duration लाई पनि

(switch off - ढिलो गरायो)

→ Self inductance of the coil is the property of a coil by virtue of which ~~del~~ it delays the growing or decaying current.

→ It is also called electrical inertia.

→ Change in flux (ϕ) ∝ current passing through the coil.

$$\phi = LI$$

where, 'L' is self inductance of coil.

again, induced emf, $\mathcal{E} = \frac{-d\phi}{dt}$

$$\boxed{\mathcal{E} = -\frac{L\,dI}{dt}}$$

· If $\frac{dI}{dt} = 1\,A/s$ then $\boxed{\mathcal{E} = L}$

→ L is defined as the induced emf when 1A current grow or decay at 1sec.

→ unit of self inductance (L) = Henry

→ Dimension of L =

Q. $L = 10H$, current in the coil decays at the rate of 2A/s. Find E.

(−)

[grows आको भए (+)]

→ $\frac{dI}{dt} = -2\ A/s$

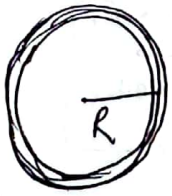
$$E = -L\frac{dI}{dt}$$

$$= 10 \times 2$$

$$= 20V \text{ Ans}$$

Self inductance for a circular current carrying coil

$$B = \frac{\mu_0 N I}{2R}$$



$$\phi = NBA$$

N = total no. of turns

$$L\cancel{I} = N\frac{\mu_0 N \cancel{I}}{2R}A$$

$$\boxed{L = \frac{\mu_0 N^2 A}{2R}}$$

$$L = \frac{\mu_0 N^2 \pi R^{\cancel{2}}}{2\cancel{R}}$$

$$\boxed{L = \frac{\mu_0 N^2 \pi R}{2}}$$

$$\boxed{L \propto N^2}$$

$$\frac{L_1}{L_2} = \left(\frac{N_1}{N_2}\right)^2$$

Self inductance for a solenoid



$\phi = NBA$

$L\cancel{I} = N \mu_0 \frac{N}{l} \cancel{I} A$ ↳ Area

N = total no. of turns

l = length of solenoid

$n = N/l$

$B = \mu_0 \frac{NI}{L}$

$$\boxed{L = \frac{\mu_0 N^2 A}{l}}$$

$\boxed{L \propto N^2}$, $\boxed{L \propto \frac{1}{l}}$

$$\boxed{L = \frac{\mu_0 \mu_r N^2 A}{l}}$$

$\mu_r \rightarrow$ relative permeability

- For ferromagnetic substance; $\mu_r \rightarrow$ large

So, $L \uparrow$es, induced emf $\uparrow$es

Q. A bulb and a coil are connected in series in the circuit. If the iron rod is placed in the coil, then intensity of the bulb --

$\mu_r \rightarrow \uparrow$es

(a) increases (b) decreases (c) Same (d) bulb will fuse

$\mu_r \uparrow$es, $L \uparrow$es,

↳ So, back emf $\uparrow$es (induced emf)

↳ then intensity $\downarrow$es.

Q. The coil is wound in a rectangular rod then ~~induced emf is~~ self inductance is L. If the linear parameters of the rod is ~~doubt~~ increased by factor 2 keeping no. of turns per unit length same. ~~Find~~ What will be the self inductance?

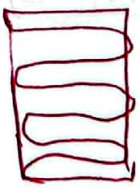
(a) L (b) $4L$ (c) $8L$ (d) $L/4$

$L = \frac{\mu_0 N^2 A}{l}$

$\left(n = \frac{N}{l}\right) \rightarrow$ same

$L' = \frac{\mu_0 N^2 A}{l^2} \times l$ (same)

$L = \mu_0 n^2 A \times l$ (same)



$A = l \times b$ $l' = 2l$

$A' = 2l \times 2b$

$= 4lb.$

$= 4A$

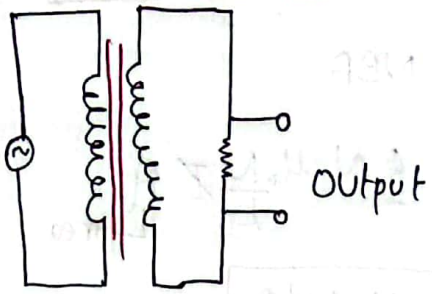
$L' = \mu_0 n^2 \times 4A \times 2l$

$= 8L.$

Mutual inductance (M)

$\Phi_s \propto i_p$

- Φ_s → change of flux in sec.
- i_p → current of primary



$$\boxed{\Phi_s = M i_p}$$

M → Mutual inductance

Induced emf is given by,

$$\mathcal{E} = -\frac{d\Phi}{dt} = -\frac{M d i_p}{dt}$$

$$\boxed{\mathcal{E} = -\frac{M d i_p}{dt}}$$

→ If $\frac{di_p}{dt} = 1A/s$ then, $\mathcal{E} = M$.

primary मा 1A/s को rate मा current grow/decay हुँदा sec मा induce हुने emf लाई M भनिन्छ।

– unit → Henry

Mutual induction for two circular coils having N_1 & N_2 turns

$$\Phi_2 = N_2 B_1 A$$

$$M i_1 = \frac{N_2 \mu_0 N_1 i_1}{2R} \times A_2$$

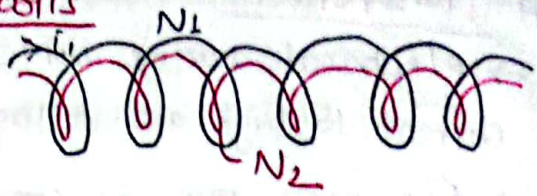


$$B_1 = \frac{\mu_0 N_1 i_1}{2R}$$

$$\boxed{M = \frac{\mu_0 N_1 N_2 \pi r^2}{2R}}$$

$$\boxed{M \propto N_1 N_2}$$

Mutual induction in two solenoid coils



$$\phi_2 = N_2 B_1 A_2$$

$$M i_1 = N_2 \frac{\mu_0 N_1 i_1}{l} \times A_2$$

$$B_1 = \frac{\mu_0 N_1 i}{l}$$

$$\boxed{M = \frac{\mu_0 N_1 N_2 A}{l}}$$

$$\boxed{M = \frac{\mu_0 \mu_r N_1 N_2 A}{l}}$$

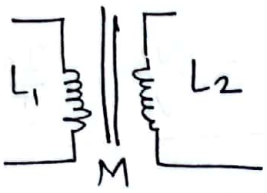
(μ_r = rel. per. of medium)

$$\boxed{M \propto N_1 N_2}$$

- M depends upon :-

1. Nature of materials
2. Geometry of coil (shape, size, no. of turns)
3. distance between the coils
4. Orientation of the coil.

$$\boxed{M = K\sqrt{L_1 L_2}}$$



K = coupling coefficient

For perfect or tightly couple coil

$$K = 1$$

$$M = \sqrt{L_1 L_2}$$

For loose coupling

$$K < 1,$$

$$M < \sqrt{L_1 L_2}$$

For uncoupled coil or large sepr

$$K = 0$$

$$M = 0$$

Transformer

→ electrical device which converts low a.c voltage at high current to high a.c voltage at low current and vice-versa.

→ Frequency remains ~~constt~~ constant. ($I_f = O_f$)

→ Transformer transforms power.

→ ~~Input~~ Principle → Mutual induction

Types

Step-up:- low voltage to high voltage.

→ $N_s > N_p$ ($N_2 > N_1$), $V_2 > V_1$ but $i_1 > i_2$.

→ Used for long distance transmission. (Hydropower to ~~घर~~)

→ low power loss.

Step-down:- High voltage to low voltage.

→ $N_1 > N_2$, $V_1 > V_2$ but $i_2 > i_p$.

→ used for short distance transmission. (Pole to House)

- For an ideal transformer → 100% efficiency

$$P_{output} = P_{input}$$

$$I_2 V_2 = I_1 V_1$$

$$\boxed{\frac{N_2}{N_1} = \frac{V_2}{V_1} = \frac{I_2}{I_1} = \sqrt{\frac{L_2}{L_1}}} \quad (L \propto N^2)$$

$$\eta = \frac{P_{output}}{P_{input}} \times 100\%$$

$$\eta = \frac{I_2 V_2}{I_1 V_1} \times 100\%$$

Transformer loss

① Flux loss → imperfect coupling (loose coupling)

② Copper loss → Loss in the form of heat.

③ Eddy loss → Variable mag. field ले गर्दा Flux मा change आयो र current passes through iron core

↳ To minimize the eddy loss → laminated iron core

④ Hysteresis loss → [illegible] of magnetization of iron core.

⑤ Humming loss → Loss in the form of sound (Humming bee)

→ Energy stored in inductor; } in the form of magnetic energy.

$$U = \frac{1}{2} LI^2$$

$$\text{Energy density} = \frac{B^2}{2\mu_0}$$

→ for straight conductor, self inductance (L) = 0

→ No emf is induced → N-S → 0

- when conductor falls freely in north-south direction
- Landing or taking off an aeroplane with its wings in N-S direction
- When coil and magnet moves, but there is no relative motion between them.

→ Emf is induced →

- When an aeroplane flies horizontally.
- Conductor falls freely in east-west direction.
- Landing or taking off an aeroplane with its wings in east west direction
- Train moves horizontally.

$$\boxed{E = BLV}$$

Abishek singh

Analogous Term

$K.E = \frac{1}{2}mv^2$

$U = \frac{1}{2}LI^2$

Mechanical	Electrical
→ Mass	→ Self inductance (L)
$= mv$ → Velocity (v) $= ds/dt$	→ Current (I) $= dQ/dt$
L ↓ I → Displacement (s)	→ Charge (Q)
$= ma$ → Momentum (P)	→ ~~Electric~~ magnetic flux (ϕ)
$= m\frac{dv}{dt}$ → Force (F)	→ Induced emf (ϵ)
↕ ↕ → K.E	→ Magnetic energy
$= L\frac{ds}{dt}$ → Tempr	→ Potential

CamScanner