Class XII Academic Program-2020

PHYSICS 2ND PAPER

Lecture : P-13

Chapter 04 : Electromagnetic Induction & Alternating Current

TODAY'S TOPICS

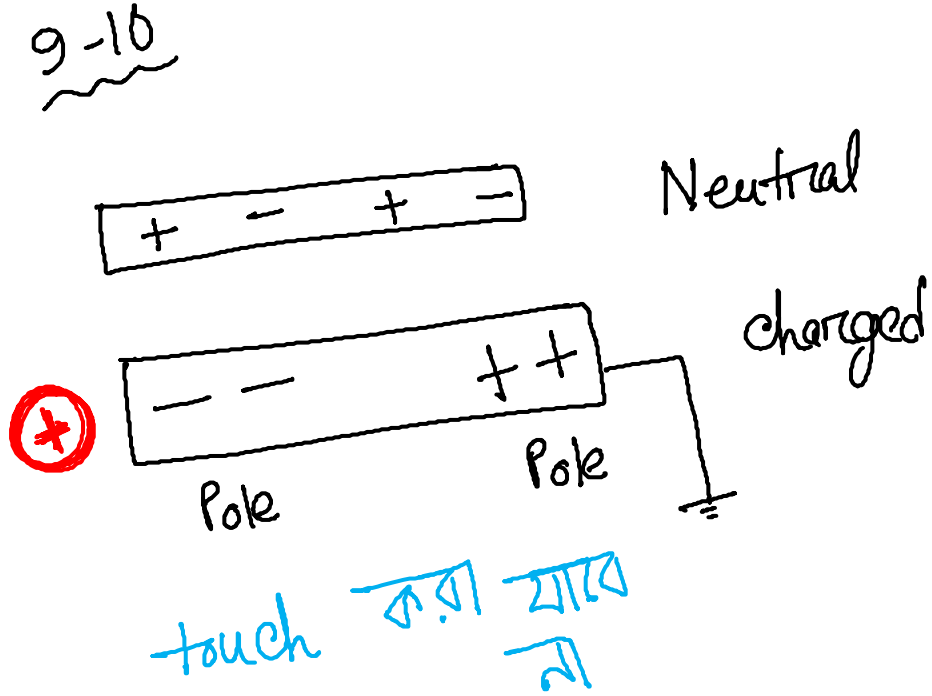
- ✓ Electromagnetic Induction
- ✓ Production of electricity by magnet
- ✓ Faraday's law
- ✓ Lenz's law and principle of conservation of energy
- ✓ Self and mutual Induction

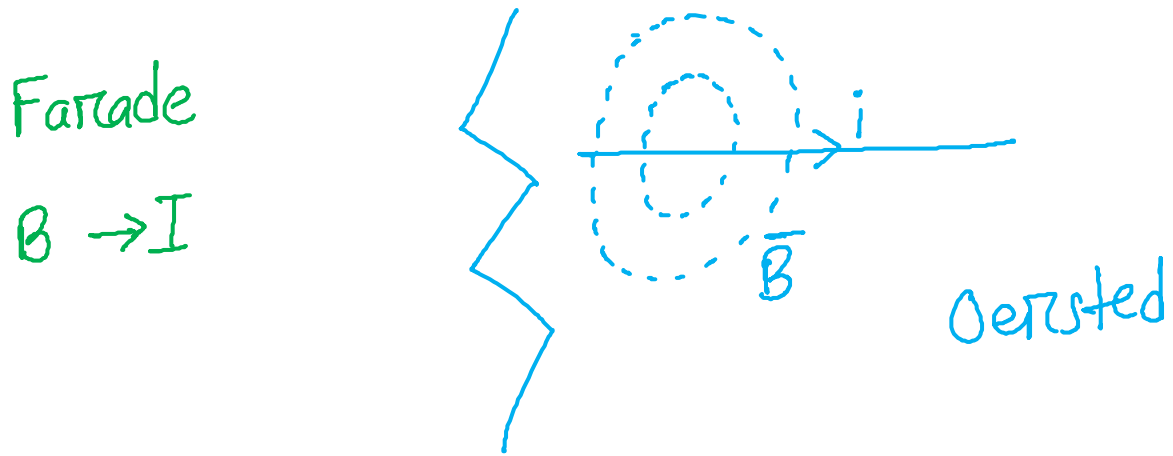
There are 3 types of induction. Ex-

(a) Static electric induction

(b) Magnetic induction

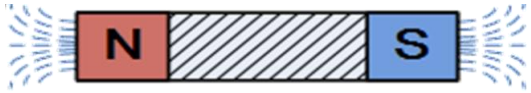
(c) Electromagnetic induction



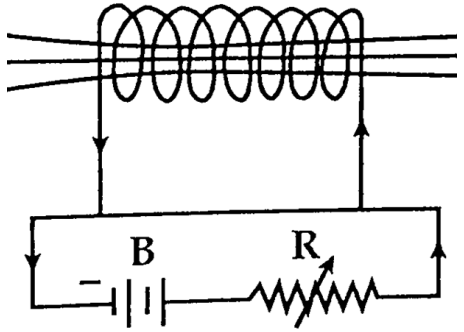


ELECTROMAGNETIC INDUCTION

Input: i) Moving bar magnet

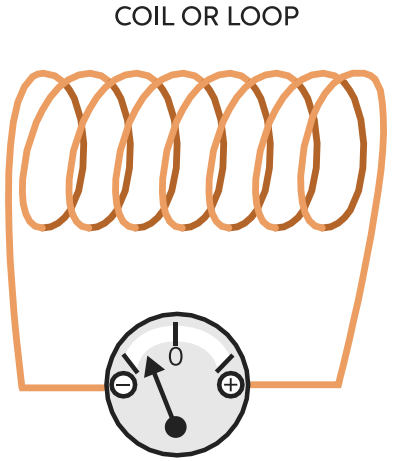


ii) Moving current flowing coil



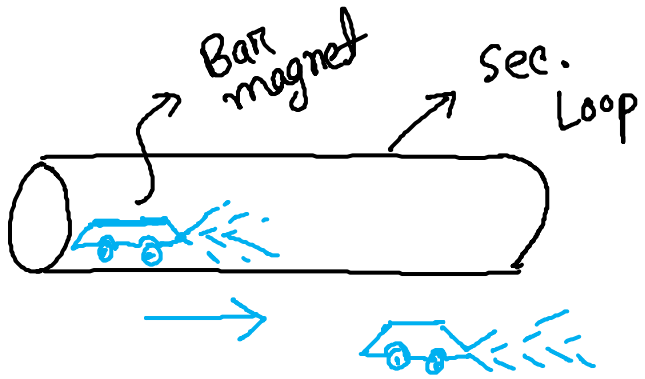
Output: Induced current or emf in a closed loop

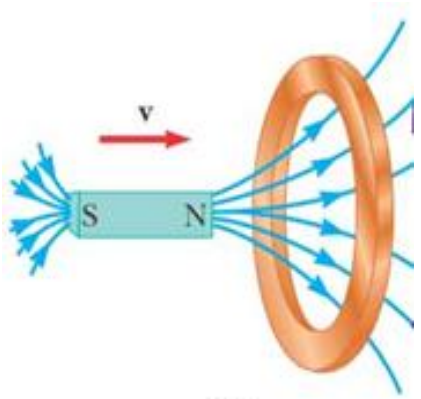
Must: ***Relative velocity has to be maintained***



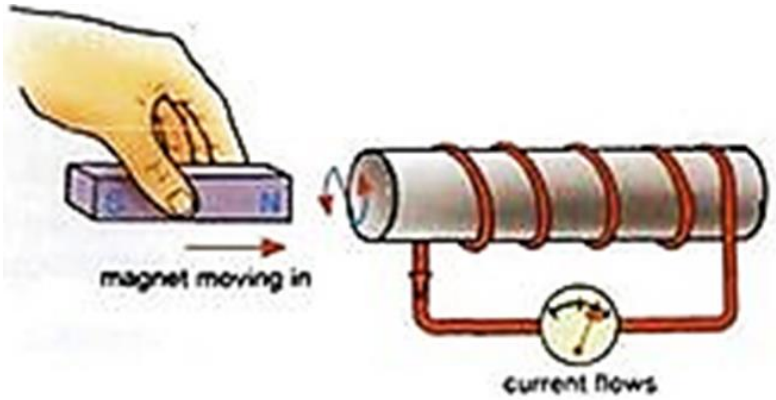
ELECTROMAGNETIC INDUCTION

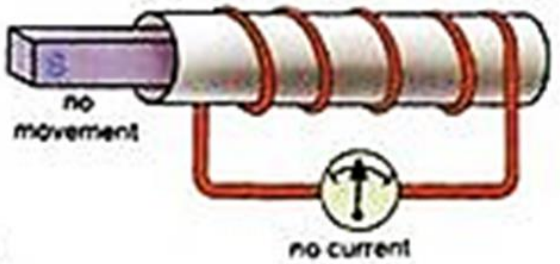
Input: i) Moving bar magnet

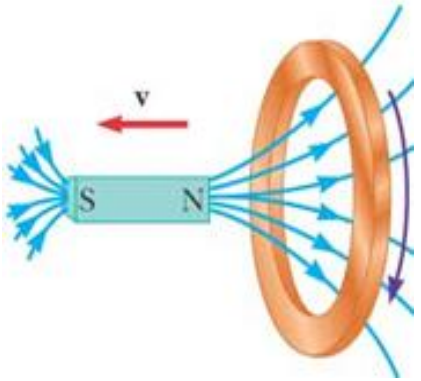


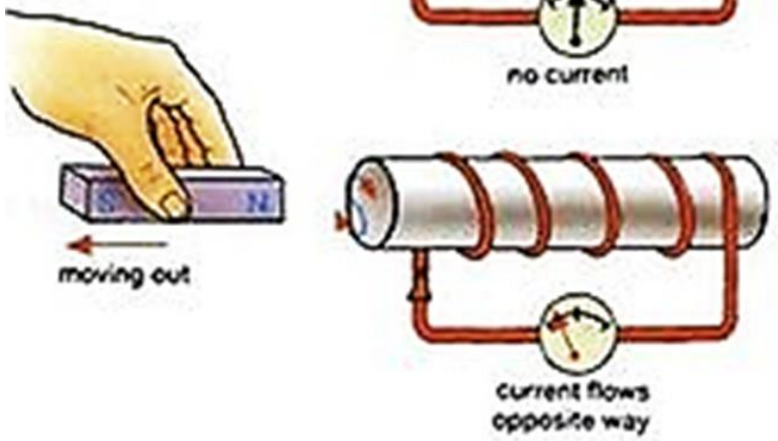


(a)



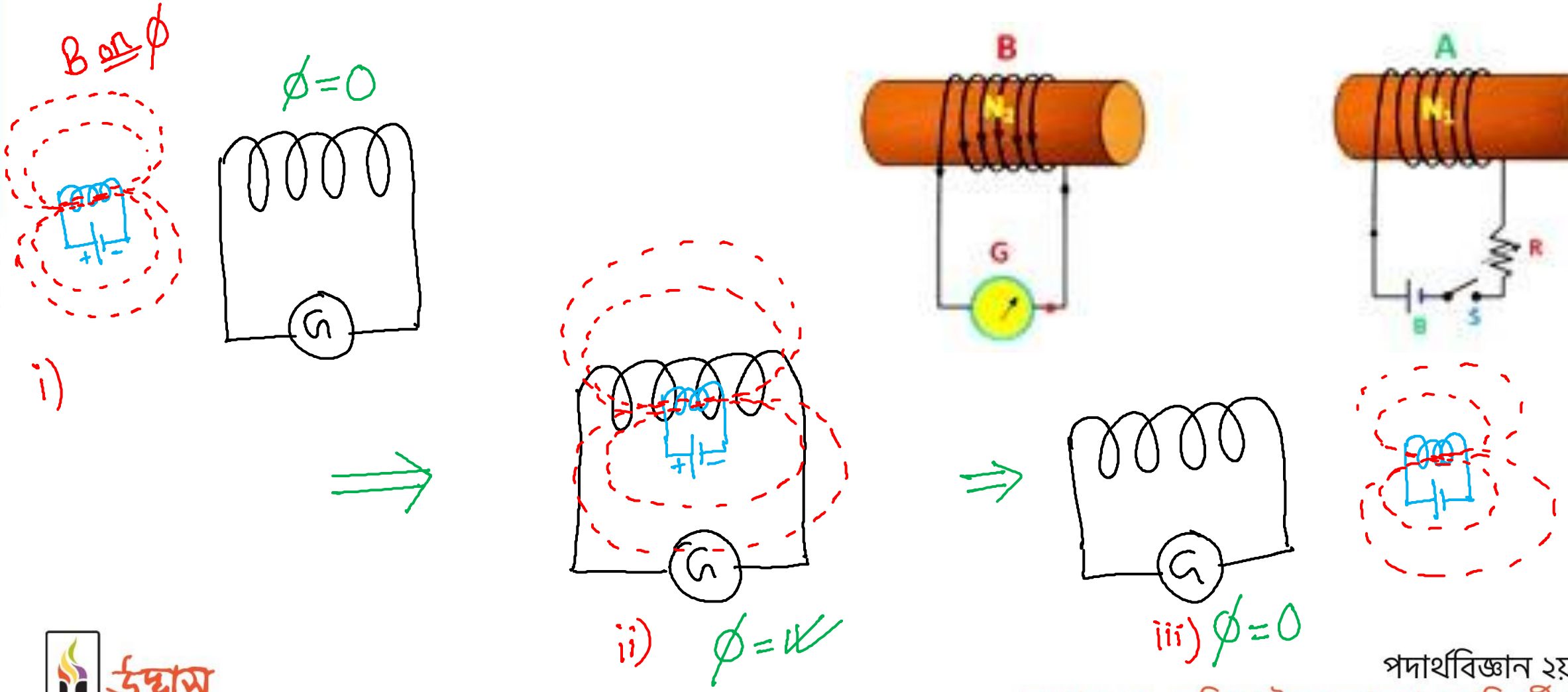






ELECTROMAGNETIC INDUCTION

Input: ii) Moving current flowing coil



POLL QUESTION 01

In which case there will be no electromagnetic induction?

(a) Relative velocity between current carrying primary coil and secondary coil

(b) Relative velocity between bar magnet and secondary coil

(c) Relative velocity between no current carrying primary coil and secondary coil

(d) No correct answer

FARADAY'S LAW

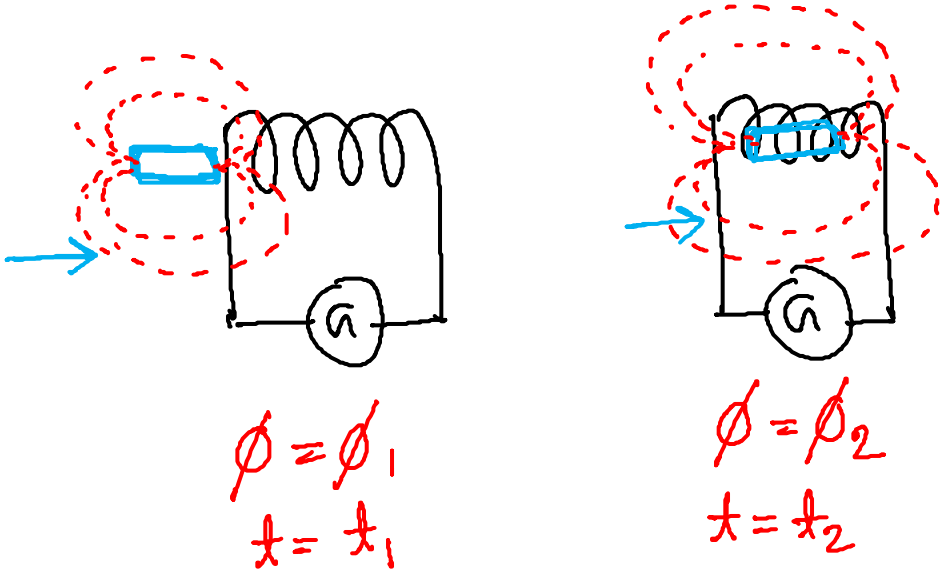
1st law: Whenever a conductor is placed in a **varying** magnetic field, an electromotive force is induced.

change in flux

FARADAY'S LAW

2nd law: The induced emf in a coil is proportional to the **rate of change** of flux linkage. $\approx$ (E)

Mathematical expression is given by Newman



change of flux, $d\phi = \phi_2 - \phi_1$

change of time, $dt = t_2 - t_1$

rate of change of flux $= \frac{d\phi}{dt}$

$= \frac{\phi_2 - \phi_1}{t_2 - t_1}$

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

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

N = turns

MATH 01

A circular coil of 20 cm diameter and 100 turns is placed in a magnetic field. Magnetic flux density is changed from 0.1T to 0.3T in 0.05 second. Determine induced electromagnetic force.

$d = 20\,cm$

$r = 10\,cm = 0.1\,m$

$N = 100$

$t = 0.05$

$B_1 = 0.1\,T$

$B_2 = 0.3\,T$

$E = ?$

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

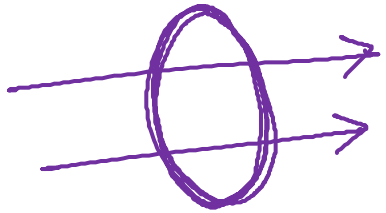
$$= 100\,\frac{d\phi}{0.05}$$

$$= \frac{100}{0.05}[\phi_2 - \phi_1]$$

$$= \frac{100}{0.05}[AB_2 - AB_1]$$

$$= \frac{100 \times \pi r^2}{0.05}[B_2 - B_1]$$

$$E = 12.57\ V$$



$B_1 = 0.1\,T$

$B_2 = 0.3\,T$

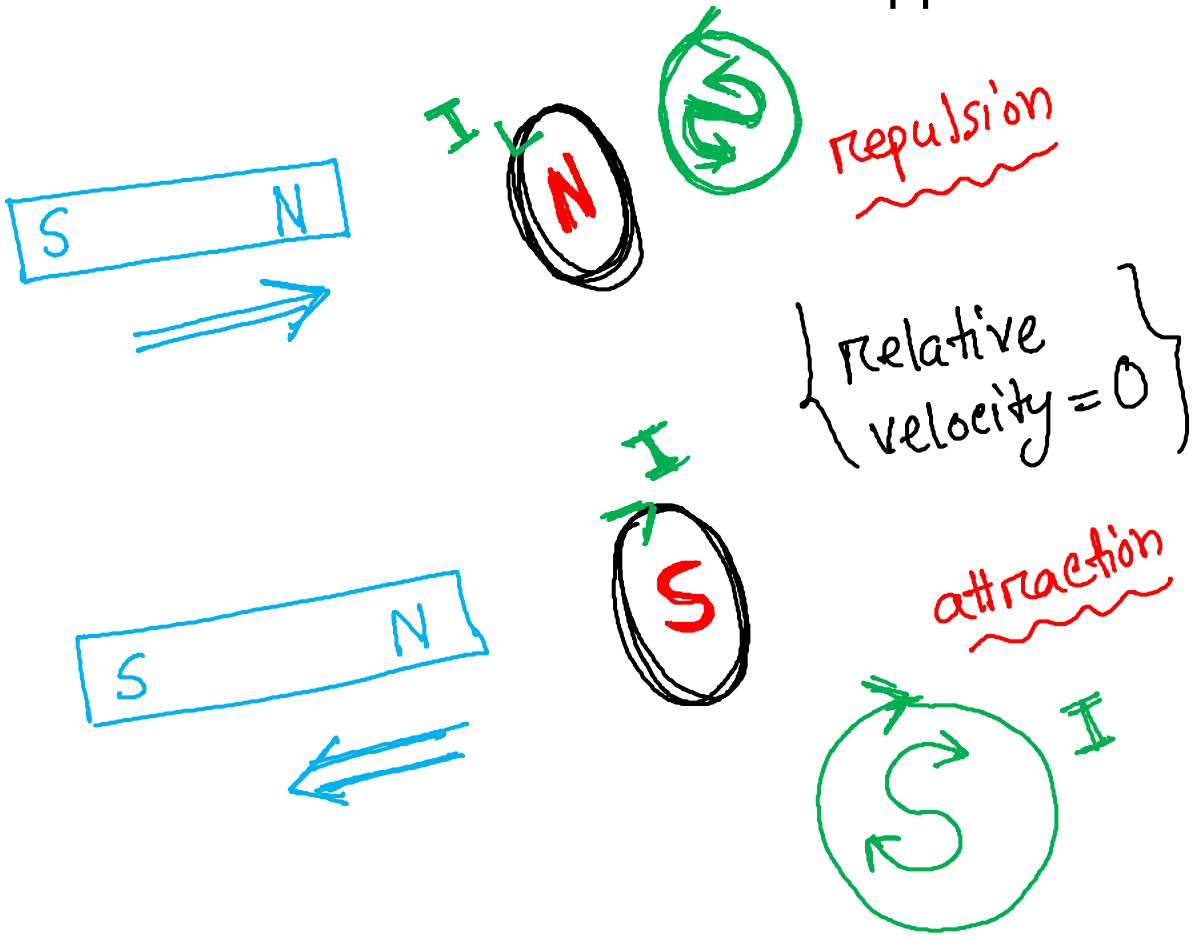
$\phi = AB\cos\theta$

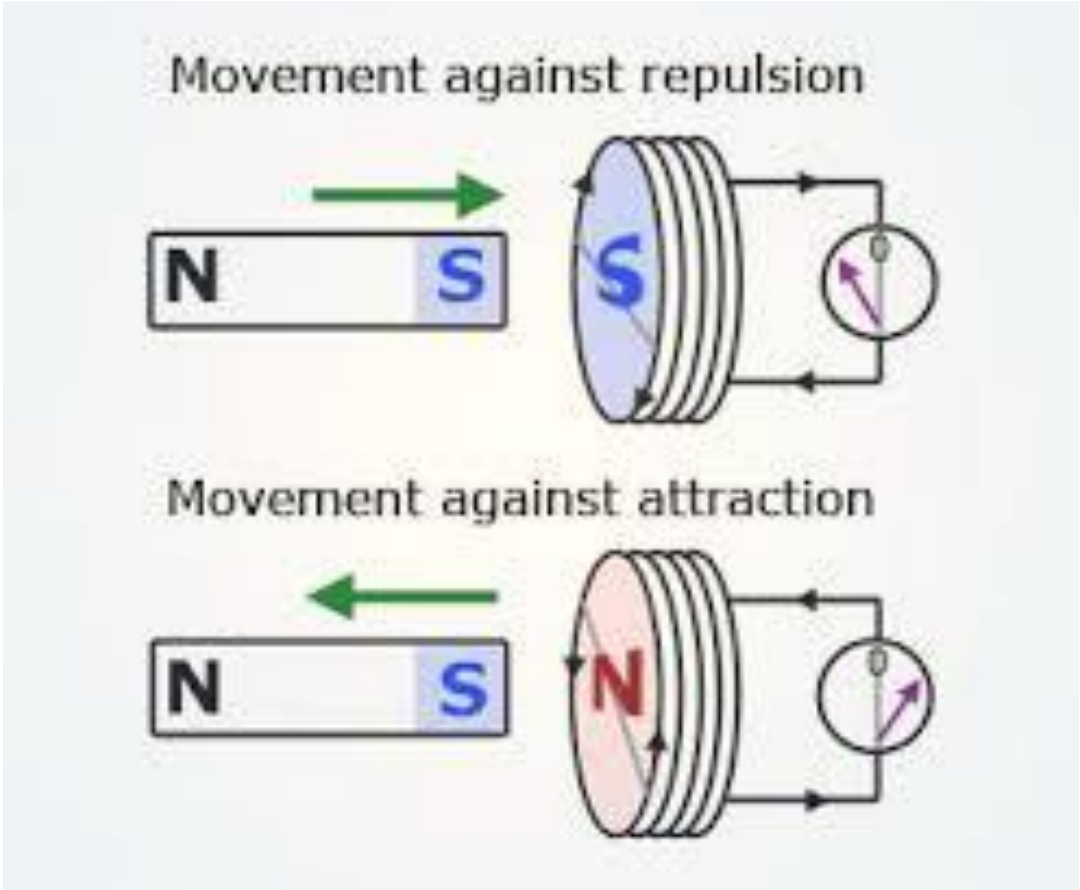
$\phi_1 = AB_1$

$\phi_2 = AB_2$

LENZ'S LAW

In case of electromagnetic induction, an induced electric current flows in a direction such that the current opposes the change that induced it.



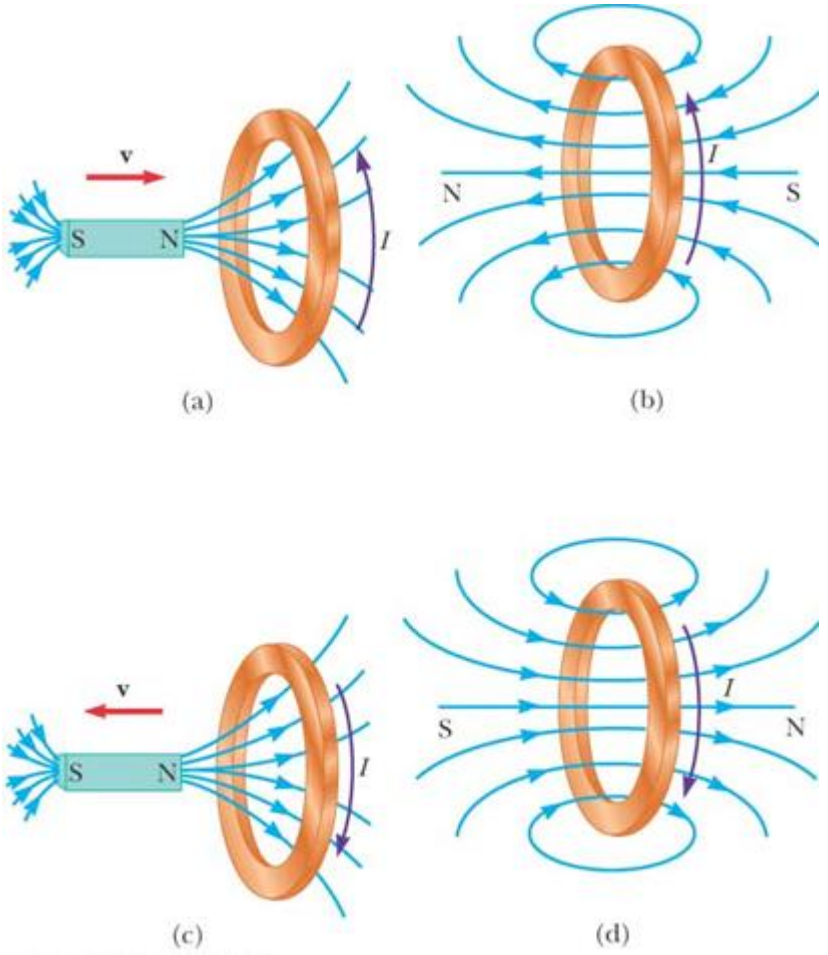


LENZ'S LAW

In case of electromagnetic induction, an induced electric current flows in a direction such that the current opposes the change that induced it.

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

$$\boxed{E = -N \frac{d\phi}{dt}}$$



POLL QUESTION 02

By whose law direction of induced current is determined?

(a) Faraday's law

(b) Maxwell's law

(c) Lenz's law

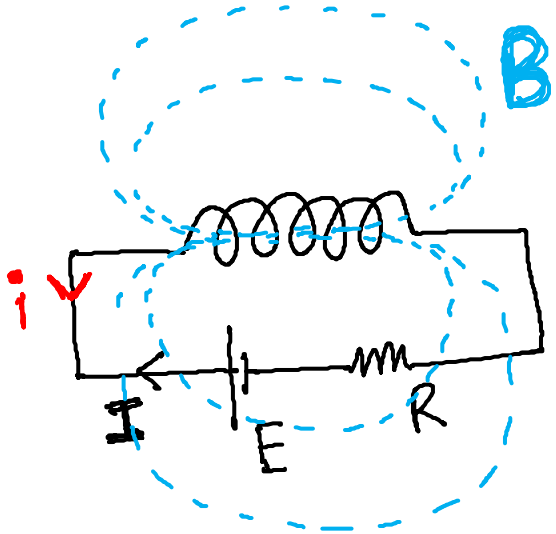
(d) Newman's law

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

SELF INDUCTION

→ Single coil
→ Varying current flow
→ Varying flux density

$\Phi \propto i$



$\phi \propto i$

$\Rightarrow N\phi \propto i$

$\Rightarrow N\phi = Li$; L unit Henry (H)

$E = \frac{d\phi}{dt} = \frac{d}{dt}(Li)$

$E = L\frac{di}{dt}$

input → output → induction

I → B → i

(Oersted) (Lenz)

Farade

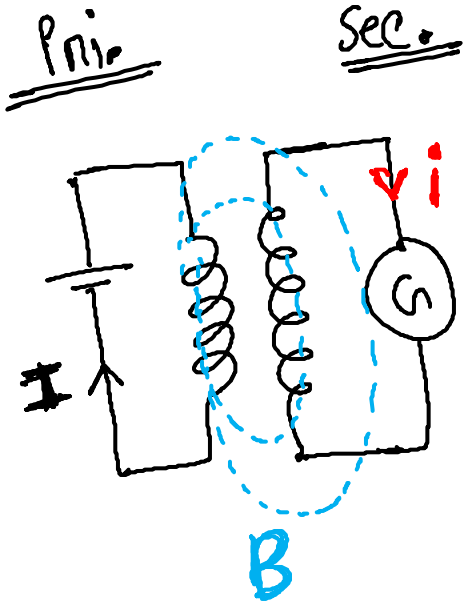
MUTUAL INDUCTION

→ **Double coil**

→ **Varying current flow**

→ **Varying flux density**

$\emptyset \propto i$



$\emptyset \propto i$

$\Rightarrow N\emptyset \propto i$

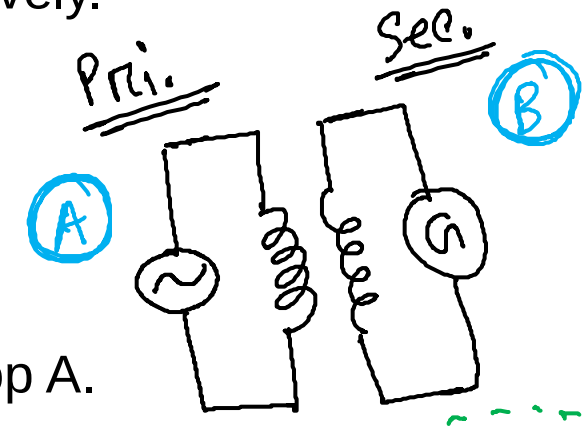
$\Rightarrow N\emptyset = Mi$; M unit Henry (H)

$$E = \frac{d\emptyset}{dt} = \frac{d}{dt}(Mi)$$

$$E = M\frac{di}{dt}$$

MATH 02

Two closely spaced coils A and B has turns 200 and 1000 respectively. Due to 2A current flow in loop A, magnetic flux in loop A and B is 0.24mWb and 0.16mWb respectively.



(a) Determine self induction.

(b) Determine mutual induction.

(c) Determine induced emf at loop B if current flow stops in 0.4 sec at loop A.

a

$N\phi = Li$

$\Rightarrow 200 \times 0.24 \times 10^{-3} = L \times 2$

$\therefore L = 0.024\ H$

(Ans.)

b

$N\phi = Mi$

$\Rightarrow 1000 \times 0.16 \times 10^{-3} = M \times 2$

$\Rightarrow M = 0.08\ H$

(Ans.)

a

$N = 200$

$I = 2A$

$\phi = 0.24\ mWb$

b

$N = 1000$

$\phi = 0.16\ mWb$

MATH 02 CONTINUED

Two closely spaced coils A and B has turns 200 and 1000 respectively. Due to 2A current flow in loop A, magnetic flux in loop A and B is 0.24mWb and 0.16mWb respectively.

(a) Determine self induction.

(b) Determine mutual induction.

(c) Determine induced emf at loop B if current flow stops in 0.4 sec at loop A.

c

$t = 0.4 \text{ sec}$

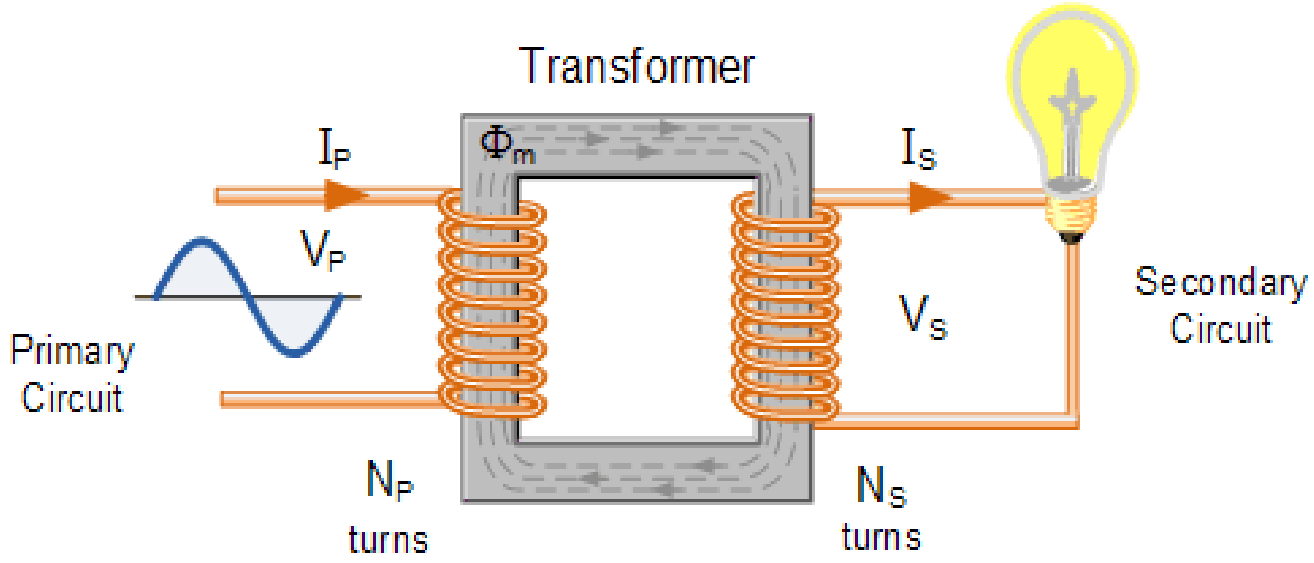
$di = (2 - 0) = 2 \text{ amp}$

$E = N \frac{d\phi}{dt}$ or $E = M \frac{di}{dt}$

$= 0.68 \times \frac{2}{0.4}$

$E = 0.4 \text{ V}$ (Ans.)

USE OF MUTUAL INDUCTION



$$P = I^2 R$$

$$R = \frac{P}{I^2}$$

$$\Rightarrow \sqrt{R} = \frac{\sqrt{P}}{I}$$

$$\therefore I \propto \frac{1}{\sqrt{R}}$$

$$E_p = N_p \frac{d\phi}{dt}$$

$$E_s = N_s \frac{d\phi}{dt}$$

$$\frac{E_p}{E_s} = \frac{N_p}{N_s} = \frac{i_s}{i_p} = \sqrt{\frac{R_p}{R_s}}$$

Turns of primary and secondary are100 and 200 respectively. If secondary coil's power is 500 watt what will be power of primary coil?

$N_p = 100$

$N_S = 200$

$P_S = 500W$

$P_p = ?$

$$\frac{E_p}{E_S} = \frac{N_p}{N_S} = \frac{i_S}{i_p} = \sqrt{\frac{R_p}{R_S}}$$

$P_p = P_S = 500W$

(Ans:)

total energy const.

$W_p = W_S$

$\Rightarrow P_p t = P_S t$

$\Rightarrow P_p = P_S$

Pri. energy = Sec. energy

Pri. power = Sec. power

Power const.

না বুঝে মুখস্থ করার অভ্যাস প্রতিভাকে ধ্বংস করে।