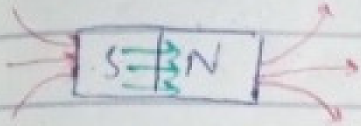
Electromagnetism

↳ study of magnetic effect of current
$I \rightarrow B$ (current produces magnetic field)

Magnet:

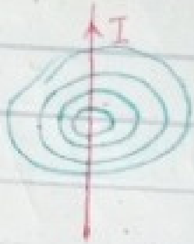
Parmanent



- magnetic field lines form a close loop

- monopole doesn't exist

Electromagnet.



Amperes Law:

$B \propto I$, $B \propto \frac{1}{r}$

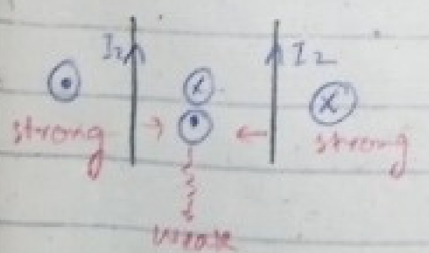
$B \propto \frac{I}{r}$

$$\boxed{B = \frac{\mu_0}{2\pi}\frac{I}{r}}$$

$\vec{B}$ is vector quantity
↳ ⊙ → out of plane
↳ ⊗ → into plane

μ_0 = permiability
$\mu_0 = 4\pi \times 10^{-7}$ Wb/mA or Tm/A

mcq:

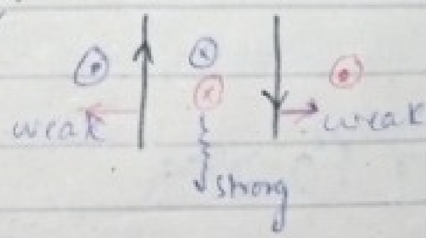


↳ Attraction.

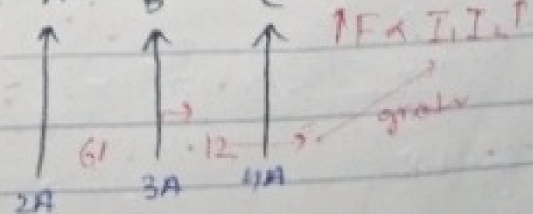
mcq: Two beams of electrons travelling same direction attract or repel

flow of e^- → I

mcq:



mcq.



The B will move towards
a: A (b) C d: None

ii: Efficiency:

ideal case: $\%\eta = 100\%$

Practically: $\%\eta \approx 90\%$

$$\eta = \frac{P_o}{P_i} \qquad \% = \frac{P_o}{P_i} \times 100$$

If $\%\eta = 65\%$

$P_i = 100$ watt

$P_o = ?$

$$\eta = \frac{65}{100}$$

$$P_o = P_i\,\eta$$

$$P_o = \cancel{100} \times \frac{65}{\cancel{100}}$$

$$\boxed{P_o = 65 \text{ watt}}$$

Energy Losses in Transformer:

i: Eddy Current:

↳ Heat

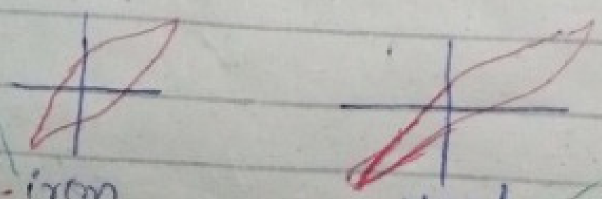
$H = I^2Rt$

when conductor sheet in magnetic field, the +ive charges start moving in circle. eddy current

↳ Laminated sheets

ii: Hysterisis loss:

200V ↓ 0V



iron

steel

220V ↓ 200V ↓ 180 ↓ 100V

∴ Energy waste in steel is large that's why it is not used in transformer

Area under graph ∝ Energy waste.

↳ quickly magnetize & demagnetize

↳ slowly magnetize and demagnetize

Magnetic Flux:

→ No of magnetic field lines passing through certain area element.

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

$\phi = BA\cos\theta$

→ scalar Quantity

→ No direction

$B = \frac{\phi}{A}$

→ magnetic induction

→ magnetic intensity.

→ magnetic field strength

→ Magnetic density

$\phi_B = B\ A$

$\boxed{Wb = T\ m^2}$

MCQ: $\vec{B} = 2i + 3j$

$\vec{A} = 2i + 4j$

$\phi = ?$

$\phi = (2i + 3j)\cdot(2i + 4j)$

$\phi = 4 + 12 = \boxed{16\,Wb}$

Force on Moving Charge In Magnetic Field

$F = ILB\sin\theta$ $\because I = \frac{q}{t}$ $\because S = vt$, $L = vt$

$F = \left(\frac{q}{t}\right)(vt)B\sin\theta$

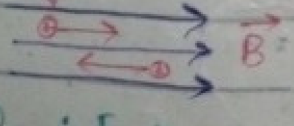
$F = qvB\sin\theta$

$F_m = 0$, only when;

* $q = 0$ (neutron, γ-gamma, photon)
* $v = 0$ (at rest)
* $B = 0$

If $\theta = 0°, 180°$:

$\boxed{F = 0}$



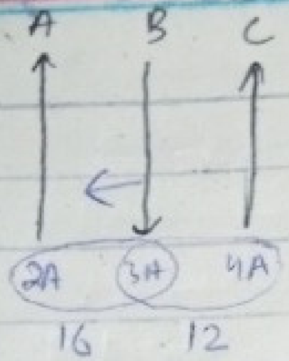
→ path: straight Line

$W = 0$ $\because F = 0$

$\Delta K.E = \Delta P.E = 0$

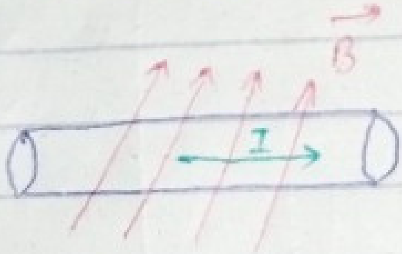
$v =$ constant

$P =$ constant



B will move towards A $\uparrow F \propto \frac{1}{I_1 I_2 \downarrow}$

Force Act On Current Carrying Cond.



$F \propto L \propto B \propto I \propto \sin\theta$

$F \propto ILB\sin\theta$

$F = KILB\sin\theta$

$\therefore K = 1$ in S.I

$\boxed{F_m = ILB\sin\theta}$

F_m is zero:

* $I = 0$ * $B = 0$
* $L = 0$ * $\theta = 0°, 180°$

F_m is maximum:

$\theta = 90°$

$F_{max} = ILB$

$B = \frac{F_{max}}{IL} = \frac{N}{Am} \Rightarrow \boxed{T = NA^{-1}m^{-1}}$

$T = (kg\,m\,s^{-2})\,m^{-1}A^{-1}$

$\boxed{T = kg\,s^{-2}A^{-1}}$

→ T is SI unit

1T = 10^4 gauss (C.G.S)

Vector Form:

$\vec{F_m} = I(\vec{L} \times \vec{B})$ → In the direction of current

$\vec{F_m} = ILB\sin\theta\,\hat{n}$

R.H.R

L.H.R] applicable for only conventional current

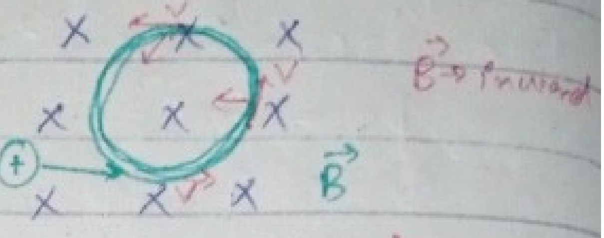
If $\theta = 90°$:

$F_{max} = qvB$

$W = 0 \quad \because d = 0$ (circle)

$v \neq$ constant

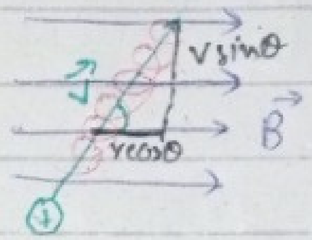
$P \neq 0$



path = circular.

If $0° < \theta < 90°$: (oblique angle)

$W = 0$



path: helicle

cos sin cos sin cos sin cos

Lorentz Force:

Sum of electric or magnetic force is called as Lorentz force.

$\vec{F}_L = \vec{F}_e + \vec{F}_m$

$\vec{F}_L = q\vec{E} + q(\vec{v} \times \vec{B})$

Velocity Selector:

$F_e = F_m$

$qE = qvB$

$v = \frac{E}{B} \left(\frac{m}{s}\right)$

$v = \frac{E}{B} = \frac{NC^{-1}}{Nm^{-1}A^{-1}} = \frac{C^{-1}}{m^{-1}A^{-1}} = \frac{mA}{C} = \frac{m}{As}$

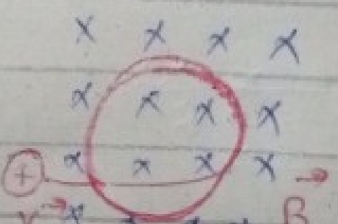
$= \left(\frac{m}{s}\right)$

Charge to Mass Ratio:

$F_m = F_c$

$qvB = \frac{mv^{2}}{r}$

$\boxed{qB = \frac{mv}{r}} \rightarrow ①$



$$v = \frac{qBr}{m}$$ $\therefore v = r\omega$

$$r\omega = \frac{qBr}{m}$$

$$\boxed{\omega = \frac{qB}{m}}$$

$\therefore \omega = 2\pi f$

$$2\pi f = \frac{qB}{m}$$

$$\boxed{f = \frac{qB}{2\pi m}}$$

$$\boxed{T = \frac{2\pi m}{qB}}$$ $T \propto m$ $f \propto \frac{1}{m}$

$T_\alpha > T_p$, no. of cycles will be less, slow movement.

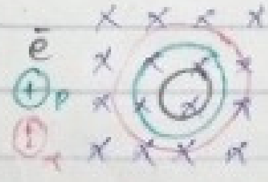
$f_\alpha < f_p$

from eq ①

$$r = \frac{mv}{qB}$$ $r \propto m$

mcq:

If $\bar{e}$, p & α enter in a uniform magnetic field with same speed w.o.f has largest radius. α



$r \propto m$

$r_\alpha > r_p > r_e$

Deflection $\propto \frac{1}{\text{mass}}$

from eq ①

$mv = qBr$

$p = qBr$ — ③

$\therefore K.E = \frac{p^2}{2m} \Rightarrow p^2 = 2mK.E$

$p = \sqrt{2mK.E}$

$\sqrt{2mK.E} = qBr$

$$r = \frac{\sqrt{2mK.E}}{qB}$$

$\therefore K.E = qV$

If $\bar{e}, p, \alpha$ enter in magnetic with same potential $r \Rightarrow$

$r_\alpha > r_p > r_e$

$$r = \frac{\sqrt{2mqV}}{qB}$$

$\therefore r \propto \sqrt{K.E}$

$\therefore r \propto \sqrt{V} \rightarrow$ potential.

$\therefore K.E = qV$

$$\frac{1}{2}mv^2 = qV$$

$v \rightarrow$ speed

$$v^2 = \frac{2qV}{m}$$

$$v = \sqrt{\frac{2qV}{m}} \quad \text{— (5)}$$

Compare (2) and (5)

$$\frac{qBr}{m} = \sqrt{\frac{2qV}{m}}$$

$$\frac{q^{\cancel{2}}B^2r^2}{m^{\cancel{2}}} = \frac{2\cancel{q}V}{\cancel{m}}$$

$$\frac{qB^2r^2}{m} = 2V$$

$$\frac{q}{m} = \frac{2V}{B^2r^2} \rightarrow \text{Charge to mass ratio in form of potential}$$

Eq (1):

$$qB = \frac{mv}{r}$$

$$\frac{q}{m} = \frac{v}{Br} \rightarrow \text{Charge to mass ratio in form of speed.}$$

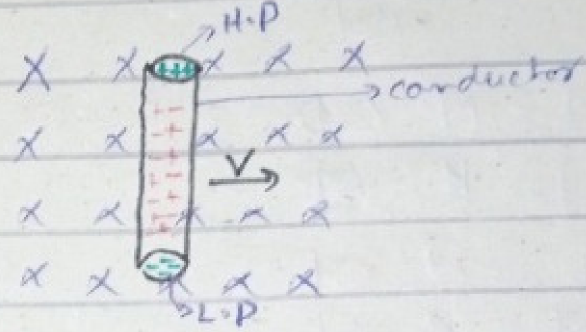
$$\left(\frac{q}{m}\right)_{\bar{e}} > \left(\frac{q}{m}\right)_p > \left(\frac{q}{m}\right)_\alpha \qquad \left(\frac{q}{m}\right)_{neutron} = 0$$

$\rightarrow 1.75 \times 10^{11}$ C/kg

Electromagnetic Induction

↳ When a conductor is moved in a magnetic field a p.d is created at the ends of conductor. This p.d is called induce emf. This phenomeon is called as E.M induction.

→ firstly conductor was neutral but when moved in $\vec{B}$ it acquired p.d.



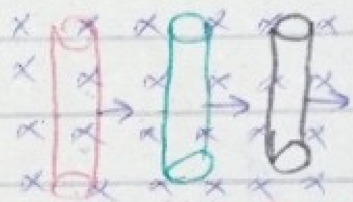
Induce Emf:

$IR = IR = IR = \text{constant}$

$2 \times 10 = 5 \times 4 = 10 \times 2 = \text{constant}$

$IR = \text{constant}$

$IR = \mathcal{E}$ → induced emf → does not depends on I & R.



$IR = IR = IR = \text{constant}$

→ $\mathcal{E}$ is constant; so it is independant of I & R.

Motional Emf:

$\mathcal{E} = -vBL$

Dependance:

$\mathcal{E} \propto v$

$\mathcal{E} \propto B$

$\mathcal{E} \propto L$

How to Increase $\mathcal{E}$?

→ Moving loop faster

→ Strong magnet

→ Larger the No. of turns.

Faradays Law Of Electromagnetic Ind.

$$\mathcal{E} \propto \frac{\Delta \Phi_B}{\Delta t}$$

$$\mathcal{E} \propto N$$

Induce emf is directly proportional to rate of change of magnetic flux and no. of turns.

$$\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$$

$$IR = N\frac{\Delta\Phi}{\Delta t}$$

$$I = \frac{N}{R}\frac{\Delta\Phi}{\Delta t}$$

$$\frac{q}{\Delta t} = \frac{N}{R}\frac{\Delta\Phi}{\Delta t}$$

$$q = \frac{N\Delta\Phi}{R}$$

$$\varepsilon = -\frac{NBA\cos\theta}{\Delta t}$$

1 square: $\boxed{A = L^2}$ $\boxed{A = L^2}$

$$\varepsilon = -\frac{NBL^2\cos\theta}{\Delta t}$$

2 Circle: $A = \pi r^2$

$$\varepsilon = -\frac{NB\pi r^2\cos\theta}{\Delta t}$$

Lenz's Law:

- Law of conservation of energy
- Used to find direction of current.

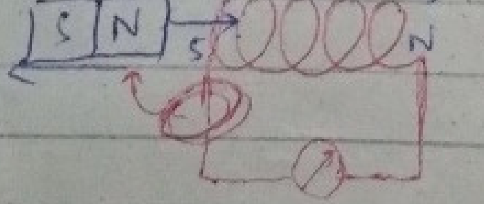
Statement:

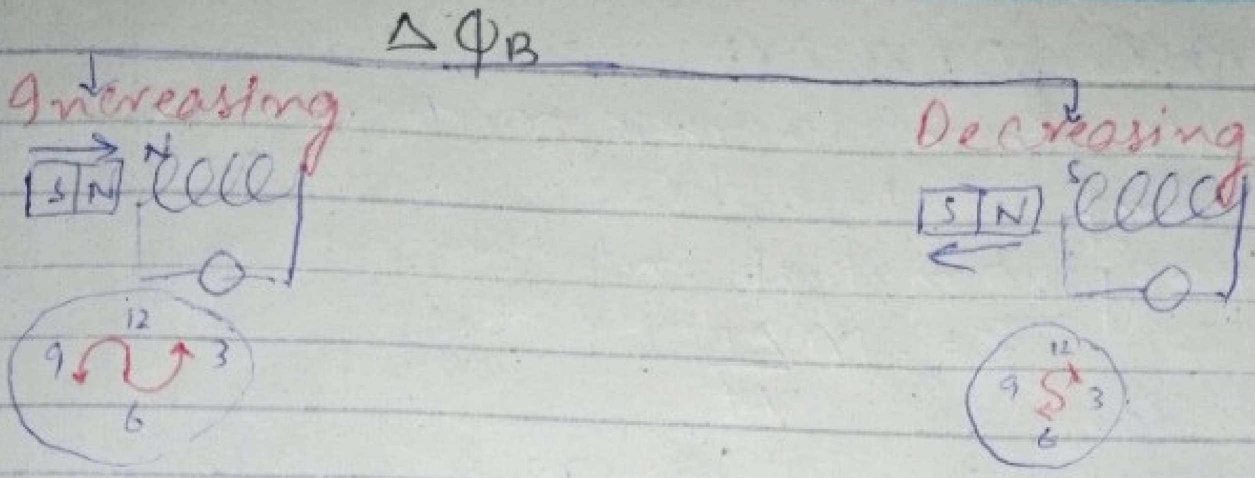
The direction of induce current in a coil is such that it opposes the cause which producing it.

$\boxed{S}\boxed{N} \; \Delta\Phi_B \rightarrow \varepsilon \rightarrow I_{induce}$

opposes the cause.

magnetic field

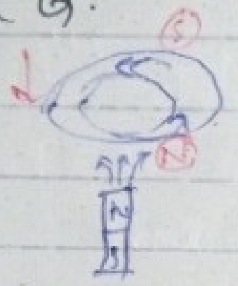




Anticlockwise

Clockwise.

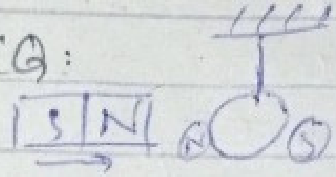
MCQ:



→ Bottom view
Anticlockwise

→ Top view
clockwise

MCQ:



Left → anticlockwise.

A.C Generator:

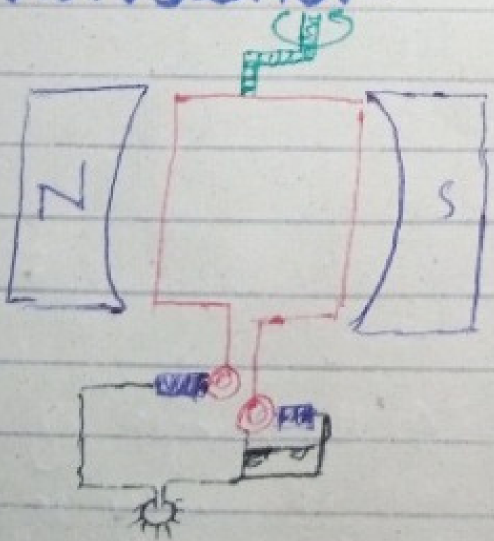
↳ mechanical energy into electrical energy

↳ Faraday's law

↳ Torque acting on current carrying conductor wire.

$\varepsilon = NIAB\cos\theta$

Construction:



$\varepsilon = N\omega AB\sin\theta$

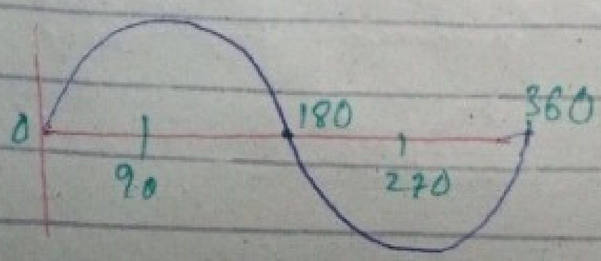
$\varepsilon = 0$ $\theta = 0°$

$\varepsilon_{max} = N\omega AB$ $\theta = 90°$

$\varepsilon = 0$ $\theta = 180°$

$\varepsilon_{max} = N\omega AB$ $\theta = 270°$

$\varepsilon = 0$ $\theta = 360°$



Transformer:

→ Device which increase or decrease Voltage and Emf ↑ or ↓ V, ε

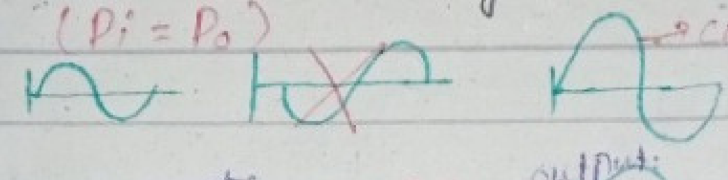
→ Principle → mutual induction

$$\varepsilon = -M \frac{\Delta I}{\Delta t}$$

Transfer doesnot change:

i: Power $(P_i = P_o)$

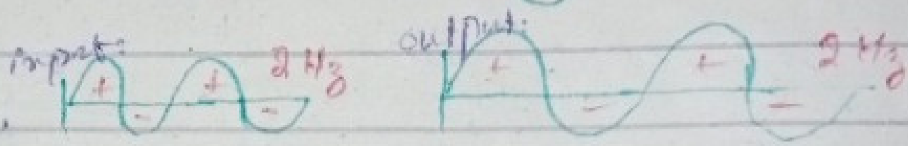
ii: Phase



→ can increase amplitude

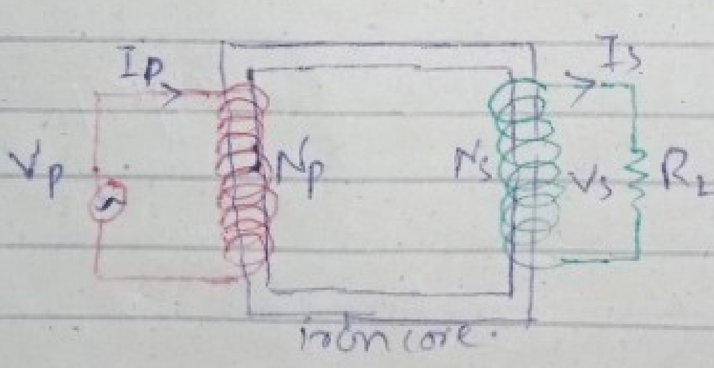
iii: Time

iv: Frequency.



Transformer doesnot perform any work on;

d.C → cell, → battery (zero) :. only A.C



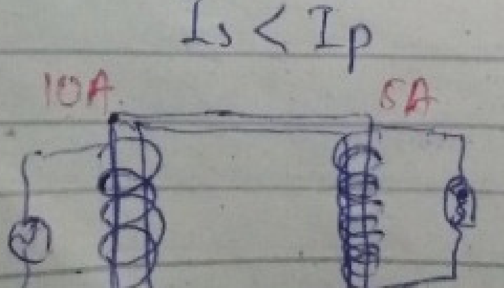
Types:

i: Step up:

$N_s > N_p$

$V_s > V_p$

$I_s < I_p$



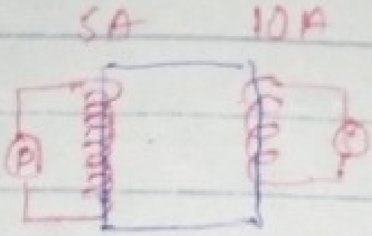
:. As the length of secondary coil is greater so its ~~long~~ Resistance will be higher than primary and current will be lower

Step Down:

$N_s < N_p$

$V_s < V_p$

$I_s > I_p$



For Ideal Transformer:

Power:

$$P_i = P_o$$

or

$$P_p = P_s$$

$$I_p V_p = I_s V_s$$

$$\frac{V_p}{V_s} = \frac{I_s}{I_p}$$

$$\boxed{V_p \propto \frac{1}{I_p}}$$

∴ Transformer doesn't obey ohms law b/c it heats up.

Transformation ration for stepup:

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

Transformation ratio for stepdown:

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

In a stepup transformer the transformation ratio is 4:3 what is $V_s = ?$ if $V_p = 3V$

$$\frac{N_s}{N_p} = \frac{4}{3}$$

$$V_p = 3V$$

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow$$

$$V_s = \frac{N_s}{N_p} \times V_p \Rightarrow \frac{4 \times 3}{3}$$

$$\boxed{V_s = 4V}$$