

FORMULA SHEET

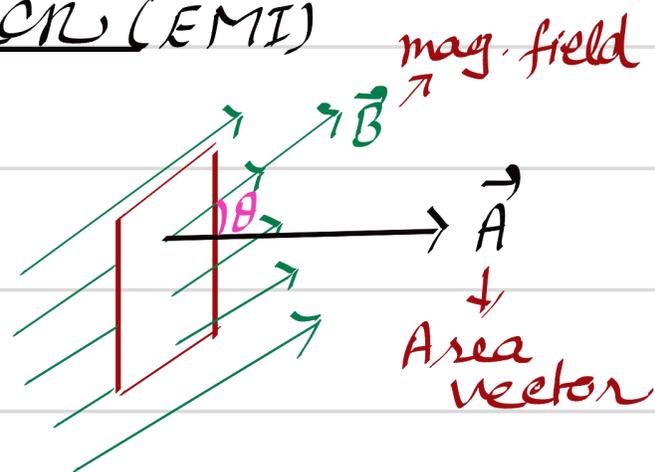
Electromagnetic Induction (EMI)

1.

Magnetic flux ( $\Phi_B$ )

$$\Phi_B = \vec{B} \cdot \vec{A} = BA \cos \theta$$

$$= \int \vec{B} \cdot d\vec{A}$$



$\theta \rightarrow$  angle b/w  $\vec{B}$  and  $\vec{A}$

2.

Faraday's law of EMI

The induced emf and induced current

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

[ -ve sign is due to Lenz's law ]  
 [  $\frac{d\phi}{dt} \rightarrow$  rate of change of flux ]

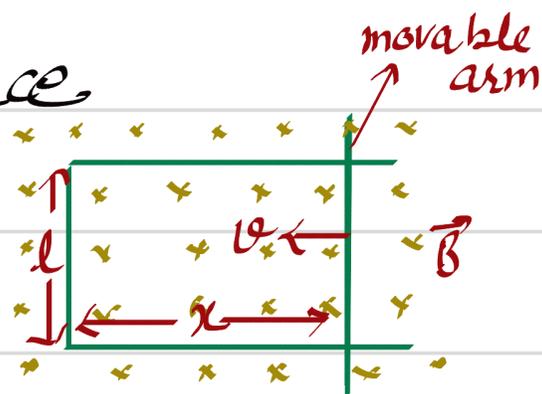
and

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

3.

Motional Electromagnetic Force

$$\mathcal{E} = Blv$$



$B \rightarrow$  magnetic field

$l \rightarrow$  length of moving arm of rectangular loop

$v \rightarrow$  speed of moving arm

$$v = -\frac{dx}{dt}$$

4.

Faraday's when Electric field is not conservative

$$\oint \vec{E} \cdot d\vec{l} = -\frac{d\phi}{dt}$$

\*  $F = qE$  still valid

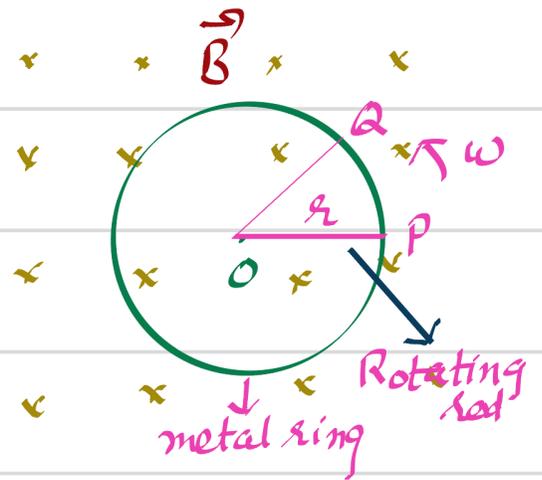
5. Emf of a Rotating Rod

$$\epsilon = \frac{1}{2} B \omega r^2$$

$B \rightarrow$  magnetic field

$\omega \rightarrow$  Angular speed

$r \rightarrow$  Radius of circular ring



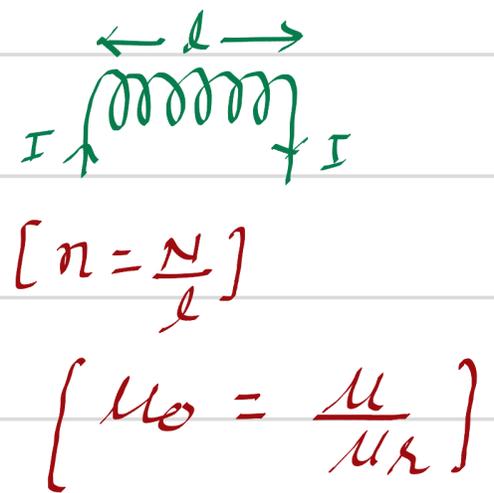
6. Self Inductance (L)

$$L = \frac{\phi}{I} = - \frac{\epsilon}{dI/dt}$$

$\phi \rightarrow$  magnetic flux,  $I \rightarrow$  current in the coil

7. Self Inductance of a Solenoid

$$\begin{aligned} L &= \mu_0 n^2 A l \\ &= \mu_0 \left(\frac{N}{l}\right)^2 A l \\ &= \frac{\mu_0 N^2 A}{l} \end{aligned}$$



$N \rightarrow$  Total no. of turn

$n \rightarrow$  no. of turns per unit length

$A \rightarrow$  Area ( $\pi r^2$  for circular coil)

8. Energy stored in an inductor

$$U_B = \frac{1}{2} L I^2$$

$L \rightarrow$  self inductance

$I \rightarrow$  current

## 9. Mutual Inductance (M)

$$M = \frac{\phi}{I} = -\frac{\epsilon}{dI/dt}$$

## 10. Mutual Inductance of two long co-axial solenoids

$$M_{12} = \mu_0 \mu_r n_1 n_2 \pi R_1^2 l$$
$$= \mu n_1 n_2 \pi R_1^2 l \quad \mu = \mu_0 \mu_r$$
$$M_{12} = M_{21}$$

and  $M_{12} = \sqrt{L_1 L_2}$

## 11. AC Generator (AC $\rightarrow$ Alternating current)

AC voltage

$$\epsilon = \epsilon_0 \sin(\omega t + \phi) \text{ or } \epsilon = \epsilon_0 \cos(\omega t + \phi)$$

$\epsilon$  or  $V$  are AC voltage produced by generator at any instant of time 't'.

$\epsilon_0$  or  $V_0$  are maximum value (peak value)

$$\epsilon_0 = NAB\omega$$

$$\omega = 2\pi f$$

$\rightarrow$  frequency of AC

$\phi$  is phase diff, for  $\phi = 0$

$$\epsilon = \epsilon_0 \sin \omega t \text{ or } \epsilon = \epsilon_0 \cos \omega t$$

@jyotisharmaphysics

AC current

$$I = I_0 \sin \omega t \text{ or } I = I_0 \cos \omega t$$

$$I_0 = \frac{\epsilon_0}{R} = \text{peak value of current}$$