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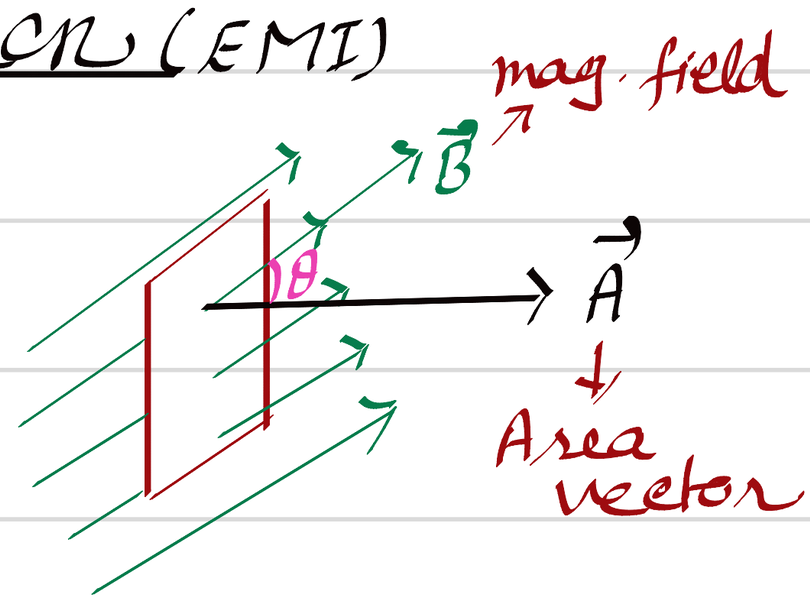
Ch·6

FORMULA SHEET

Electromagnetic Induction (EMI)

1. Magnetic flux (ϕ_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

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

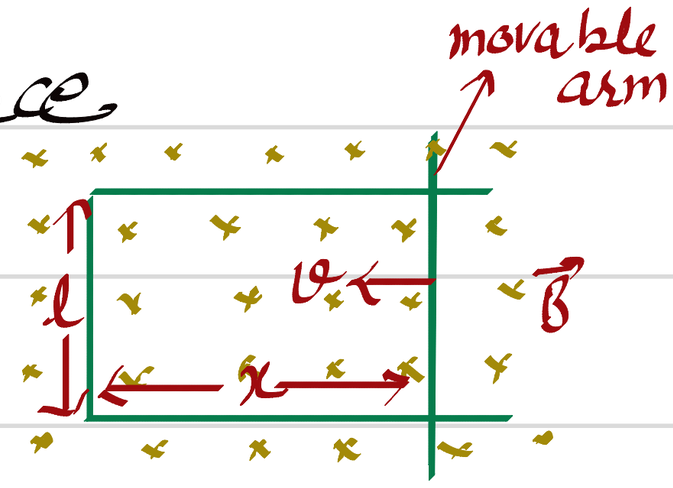
[-ve sign is due to Lenz' law]

[$\frac{d\phi}{dt}$ → 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

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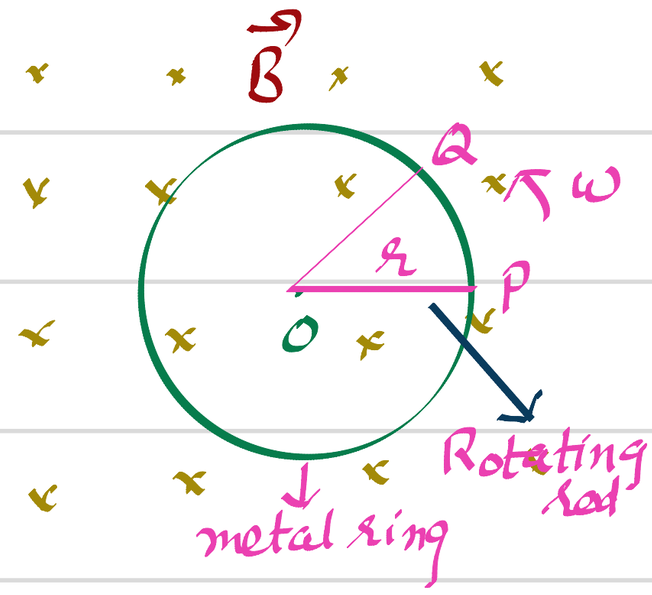
5. Emf of a Rotating Rod

$$\varepsilon = \frac{1}{2} B \omega R^2$$



$B \rightarrow$ magnetic field

$\omega \rightarrow$ Angular speed

$R \rightarrow$ Radius of circular ring

6. Self Inductance (L)

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

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

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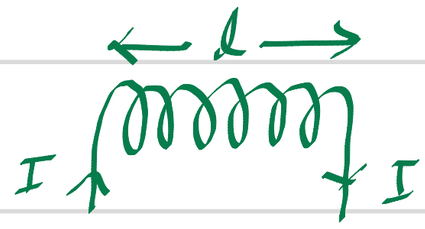
7. Self Inductance of a Solenoid

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



$\left[n = \frac{N}{l}\right]$

$\left[\mu_0 = \frac{\mu}{\mu_R}\right]$

$N \rightarrow$ Total no. of turn

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

$A \rightarrow$ Area (πR^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)

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

10. Mutual Inductance of two long co-axial solenoids

$$M_{12} = \mu_0 \mu_R n_1 n_2 \pi r_1^2 l$$

$$= \mu n_1 n_2 \pi r_1^2 l \qquad \mu = \mu_0 \mu_R$$

$$M_{12} = M_{21}$$

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

11. AC Generator (AC → Alternating current)

AC Voltage

$$\mathcal{E} = \mathcal{E}_0 \sin(\omega t + \phi) \quad \text{or} \quad \mathcal{E} = \mathcal{E}_0 \cos(\omega t + \phi)$$

$\mathcal{E}$ or V are AC voltage produced by generator at any instant of time 't'.

$\mathcal{E}_0$ or V_0 are maximum value (peak value)

$$\mathcal{E}_0 = NAB\omega$$

$\omega = 2\pi f$ → frequency of AC

ϕ is phase diff, for $\phi = 0$

$$\mathcal{E} = \mathcal{E}_0 \sin\omega t \quad \text{or} \quad \mathcal{E} = \mathcal{E}_0 \cos\omega t$$

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AC current

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

$I_0 = \frac{\mathcal{E}_0}{R}$ = peak value of current