

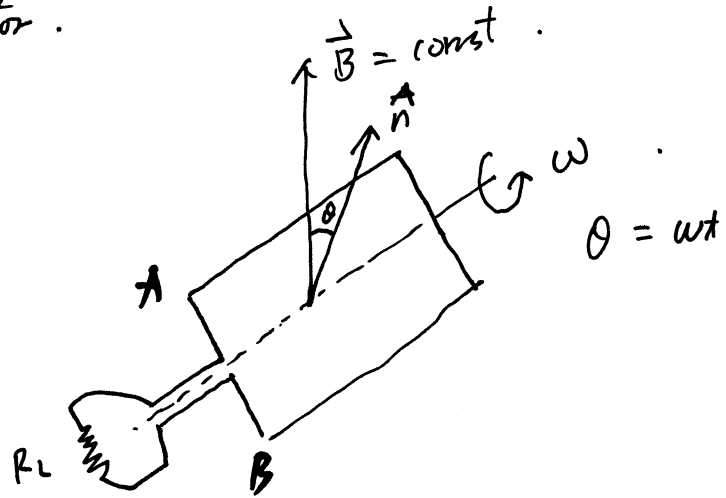
Phys 221.

Lecture 19.

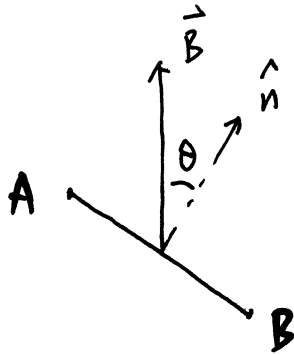
Ref: 6-5, 6-6, 6-7*
6-8, 6-9, 6-10.

• The electromagnetic generator.

fig. 6-12. (p. 181)



front view.



$$\text{flux } \bar{\Phi} = \int \vec{B} \cdot d\vec{s} = BA \cos \theta$$

$$\bar{\Phi}(t) = BA \cos(\omega t)$$

$$V_{\text{emf}} = - \frac{d\bar{\Phi}}{dt} = BA \omega \sin(\omega t)$$

Alternating current.

What if $\vec{B}$ is also t -dependent?

$$\vec{B} = B_0 \cos(\omega t)$$

$$\text{Then: } \bar{\Phi}(t) = B_0 A \cos^2(\omega t)$$

$$V_{\text{emf}} = - \frac{d\bar{\Phi}}{dt} = 2 B_0 A \cos(\omega t) \sin(\omega t) \cdot \omega$$

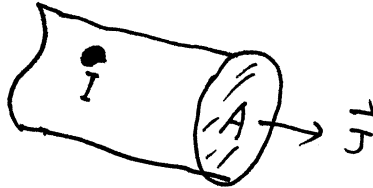
$$= B_0 \omega A \sin(2\omega t) \quad \left(\sin^2 x = 2 \sin x \cos x \right)$$

• charge-current continuity relation

$$\nabla \cdot \vec{J} = - \frac{\partial \rho_v}{\partial t} \quad 6.54$$

What does it mean?

$$I = \int_A \vec{J} \cdot d\vec{s}$$



$$= \frac{Q}{\Delta t} = \frac{\text{amount of charge through } A}{\text{per unit time}}$$

Total current going out of ~~an~~^a closed surface S :

$$\oint_S \vec{J} \cdot d\vec{s} = - \frac{dQ}{dt} \cdot \left(\begin{array}{l} \text{decreasing in } Q \\ \text{per unit time} \\ \text{in } V \end{array} \right)$$

$$= - \frac{d}{dt} \int_V \rho_v dV$$



Q - charge in V
(V - enclosed volume)

$$\int_V (\nabla \cdot \vec{J}) dV = - \int_V \frac{\partial \rho_v}{\partial t} dV$$

This is true for any volume V

$$\therefore \nabla \cdot \vec{J} = - \frac{\partial \rho_v}{\partial t} \quad (\text{charge is the source of current})$$

$$\text{OR: } \nabla \cdot \vec{J} + \frac{\partial \rho_v}{\partial t} = 0 \quad (\text{conservation of electric charge})$$

e.g. In a DC circuit, $\frac{\partial \rho_v}{\partial t} = 0$.

$$\nabla \cdot \vec{J} = 0$$

i.e. $\oint_S \vec{J} \cdot d\vec{s} = 0$ for any closed S .

in a node of a DC circuit:

$$\sum I_{\text{out}} = 0$$

That's Kirchhoff's
current law.

