HY121: Applied Physics for Engineers

Magnetism (part-4)

LECTURE # 19

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Outlines

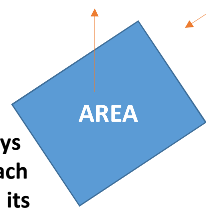
1. Electromagnetic Induction
2. Motional Emf

Electromagnetic Induction

The phenomenon in which changing magnetic flux through a coil, induces an emf in it.

AREA VECTOR

Area and Area Vector



Area and Area vector is always mutually perpendicular to each other. So if area rotates then its area vector will also rotate with it.

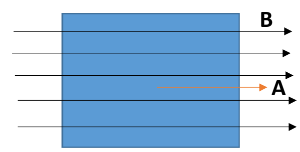
Magnetic Flux

- **The dot product of magnetic field and area vector of flat surface.**
- **It also defines as the number of magnetic field lines passing through an area which is held perpendicular to the magnetic field.**

Mathematically,

$$\boldsymbol{\varphi_B = B \cdot A}$$
$$\boldsymbol{\varphi_B = BAcos\theta}$$

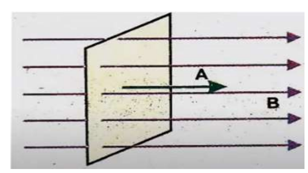
Unit: Weber = Tesla.m^2
Quantity: Scalar



Magnetic flux at different orientation

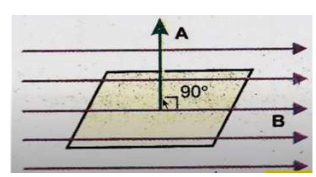
a) Magnetic flux when Area is perpendicular and area vector parallel to Field:

$$\boldsymbol{\varphi_B = B \cdot A}$$
$$= BAcos\theta$$
$$= BAcos0$$
$$= BA\ (Max)$$



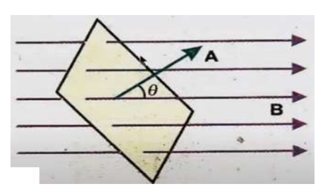
b) Magnetic flux when Area is parallel and area vector perpendicular to Field:

$$\boldsymbol{\varphi_B = B \cdot A}$$
$$= BAcos\theta$$
$$= BAcos90$$
$$= 0\ (Min)$$



c) Magnetic flux when Area and area vector making angle with Field:

$$\boldsymbol{\varphi_B = B \cdot A}$$
$$= BAcos\theta$$



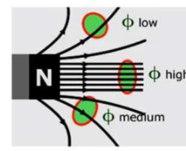
Magnetic Flux Density

- The amount of magnetic flux in an area taken perpendicular to the magnetic flux's direction.

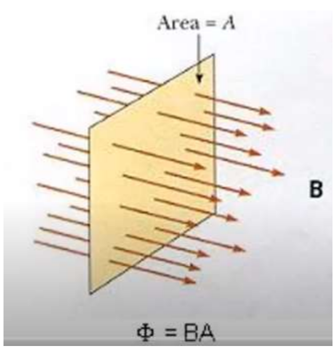
$$\text{Tesla} = \frac{\text{weber}}{m^2}$$

i. **Formula:**

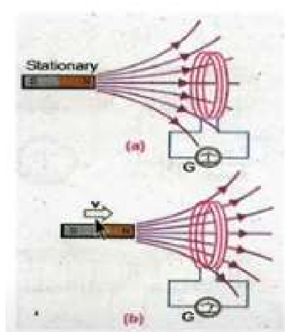
$$B = \frac{\varphi}{A}$$



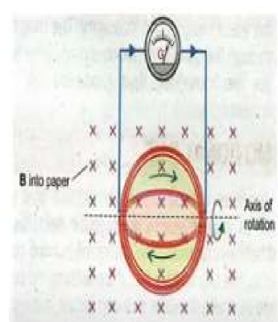
Magnetic flux and Change in magnetic flux



$\Phi = B.A$



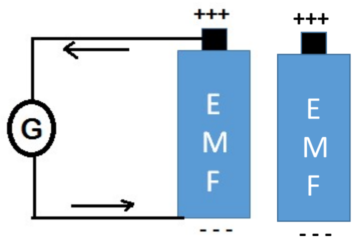
$\Delta\Phi = \Delta B.A$



$\Delta\Phi = B.\Delta A$

Back to Electromagnetic Induction…

The phenomenon in which changing magnetic flux through a coil, induces an emf in it.

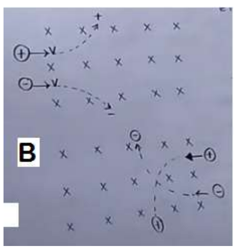


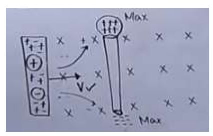
EMF / Current

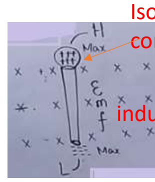
EMF

Work done on a unit positive charge by the battery/cell

Basic Idea

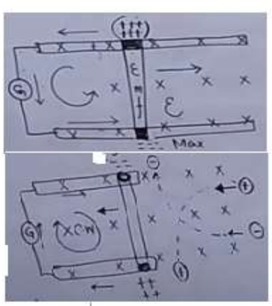






Dependance of EMF

- Strong B
- High speed
- Greater no. of loops
- Independent of resistance of the conductor



Induced current depends upon resistance.

$$i = \frac{\varepsilon}{R}$$

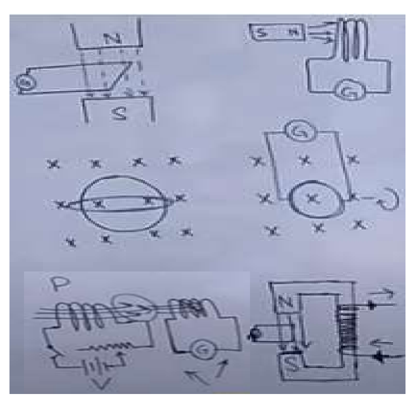
For a specific *v*, *B* & *N*

$\varepsilon = i \times R = const$

$\varepsilon = i \times \mathbf{R}$

$\varepsilon = \mathbf{i} \times R$

Some Examples for understanding Changing in Magnetic flux



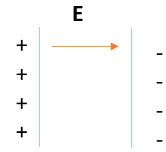
Motional EMF

EMF induced in a conductor due to its motion in the magnetic field

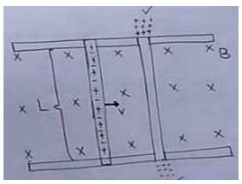
$$\varepsilon = -vBLSin\vartheta$$

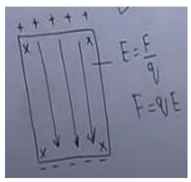
Just to recall……

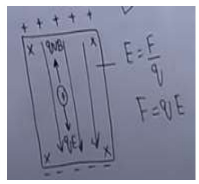
- **Electric field as potential gradient** $\boldsymbol{E} = -\frac{\Delta \boldsymbol{V}}{\Delta \boldsymbol{r}} = -\frac{\Delta \boldsymbol{V}}{\boldsymbol{L}}$

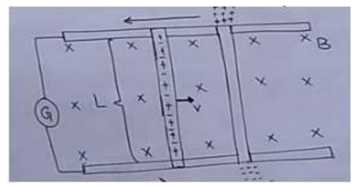


Diagrams









Derivation

Electric force = magnetic force

$qE = qvB$

$E = vB$ …. (1)

Because

$$E = -\frac{\Delta \boldsymbol{V}}{\boldsymbol{L}}$$

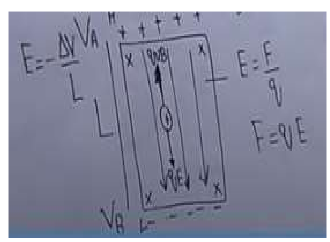
Using in eq(1)

$$-\frac{\Delta \boldsymbol{V}}{\boldsymbol{L}} = vB$$

$\Delta V = -vBL$

$\mathcal{E} = -vBL$ (max)

$\mathcal{E} = -vBLSin\theta$



END OF LECTURE