Electrodynamics

In electrodynamics,
Changing electric & magnetic field with time.
Now, the fields are time variable.
Static mag. field is produced by steady current.
" electric " " " charge at rest.

Steady Current – charges are not accumulating anywhere.
If Current I is the fun^n of time then Magnetic field will also be the fun^n of time.

$$I(t) \longrightarrow B(t)$$

& If Mag. field is time dependent then Mag. field & elec. field are dependent on each other.
Time dependent mag. field can produce time dependent Elec. field
" " Elec. " " " " Mag. "

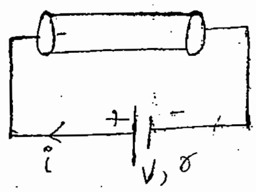
$$I(t) \rightarrow B(t) \rightarrow E(t)$$

ElectroMotive force (emf) :-

Electromotive force is Work done per unit charge.
emf is denoted by $\mathcal{E}$,

$$\mathcal{E} = -\int \vec{E} \cdot d\vec{l}$$

$\vec{F} \cdot d\vec{l}$ is Work done ~~/unit charge~~
$\vec{E} \cdot d\vec{l}$ Work done per unit charge
If we have a wire connected to battery then it is conducting & battery supply the force then free charge in wire are in motion & produce work. This work is done by battery. This work done is emf.
If battery pot^n is $V - iR$
Internal resistance is r

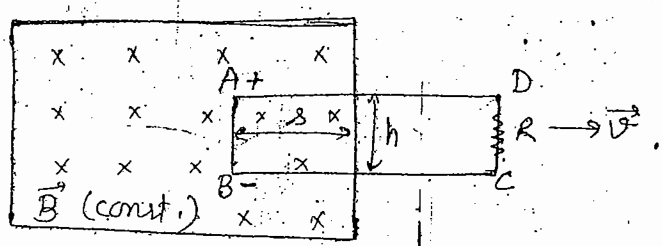


then By Bettery do work by this pot^n $V - iR$. So emf or work done per unit charge is $\Rightarrow$ emf $\varepsilon = V - ir$

Motional Electromotive force (emf) :-

Generators uses motional emf concept to generate power. This type of emf arrises when a conducting loop moves in a constant mag. field i.e. $\vec{B}$ remains constant with time.

Let us consider a wooden block. In this we have a closed loop. A resistance is connected with loop.



If someone is pulling the loop then mag. flux changes.

∵ Mag. flux passes through a closed surface is always zero.

$$\phi_m = \int_S \vec{B} \cdot d\vec{s} \qquad \left\{ \phi_m = \oint \vec{B} \cdot d\vec{s} = 0 \right.$$

$$\varepsilon = -\frac{d\phi_m}{dt}$$

This is closed loop but open surface bcoz closed surface bound some volume.

It works on Faraday's law.

Acc. to Faraday law,

Changing flux always induces the emf & dir^n of emf is s.t. it oppose the change.

If flux is ↑ then dir^n of emf is s.t. try to ↓ it. i.e. we take −ve sign.

i.e. $\boxed{\varepsilon = -\dfrac{d\phi_m}{dt}}$ ⟶ Faraday's law

⟹ Change in flux can be of 3 types.

(i) Either change $\vec{B}$, or (ii) change area ds or (iii) change the angle b/w $\vec{B}$ & $d\vec{s}$. $\phi_m = \int_S B\,ds\cos\theta$

In Case of Motional emf,
B is always constant.
So flux can be changed due to either by changing area or by change angle b/w them.
If we pull the loop out then s will varry so area will change.
To find motional emf, we use formula,

$$\boxed{\mathcal{E} = \oint \vec{f}_{mag} \cdot d\vec{l}}$$

$\vec{f}_{mag} \rightarrow$ Magnetic force per unit charge.

$\Rightarrow$ In the present Case, when loop is pulled with vel. $\vec{v}$ then amount of emf = ? Current in resistance & dir = ?

If a charge is moving with vel. $\vec{v}$ in mag. field $\vec{B}$ then force on charge

$\vec{f}_{mag} = \vec{v} \times \vec{B}$ if charge is +ve

$f_{mag} = \vec{B} \times \vec{v}$ if " " -ve

Here Conside charge is +ve. for +ve charge the dir^n of f_{mag} will be upward. A $\rightarrow$ +ve
& force on e^- will be downward. B $\rightarrow$ -ve

Current will flow due to motion of charges.
Now part AB will behave like a battery. & Current will flow from +ve to -ve terminal. i.e. A $\rightarrow$ B.
If AB is perfect conducting wire then its resistance = 0.
Hence AB part of loop is only contributing to the emf.

$$\mathcal{E} = \oint \vec{f}_{mag}\, d\vec{l}$$

$$= vB \int dl$$

$$\boxed{V = \mathcal{E} = vBh}$$

& current $V = iR \Rightarrow i = \frac{V}{R}$