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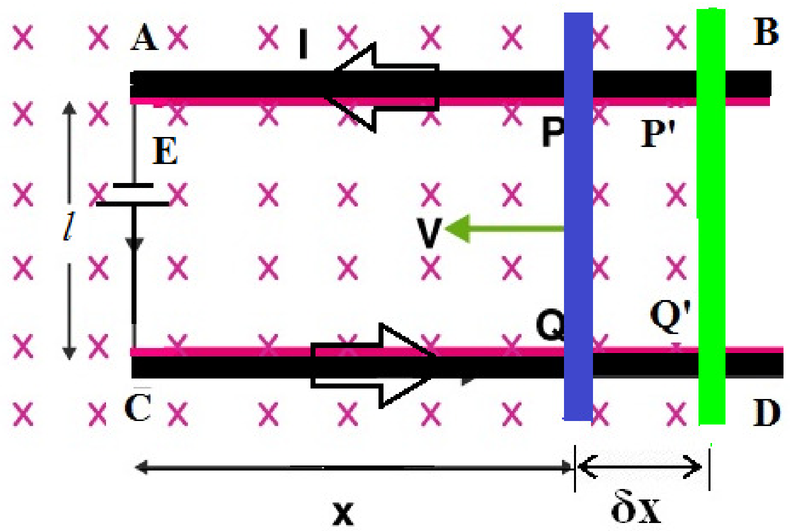
INDUCED e.m.f.(ప్రేరిత విద్యుచ్ఛాలక బలం)

Consider two copper strips AB and CD, which form parallel rails connected to a battery 'E' as shown in the following figure. Let a PQ be a another copper strip which can slide in the two rails.



The aim this topic is to derive an expression for induced e.m.f., which contains all the laws of electromagnetic induction

For this purpose, let B=magnetic field which acts perpendicular to the plane of rails (into the paper)

l=distance between the two rails AB and CD

i_0=steady current passes through the circuit.

Now, the force F_0 experienced by the rod PQ is given by $F_0=Bi_0l$.

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Due to this force, the rail moves towards right direction and reaches a new position P′Q′(Fleming's left hand rule) and travels a distance of δx in a small time δt. As the rod moves, the fux through the rod due magnetic field B changes due to which an induced e.m.f. is developed. This causes the current i_0 to change. Let the new value of current is i.

Therefore, the work done δW due to the force F is given by δW=F. δx

The energy required to do this work is derived from the battery. This is given by Ei δt. Where, E is e.m.f. of the battery which maintains a current i for a time δt.

The derived energy from the battery is utilized in two ways. One way is the energy utilized in overcoming the resistance which appears as heat. Second way is the energy utilized in moving the rod PQ.

Therefore, the total work done = work done in heating +work done in moving the rod PQ

$$\mathrm{Ei}\,\delta t = i^2 R\delta t + (\mathrm{Bil})\delta x \Longrightarrow E = iR + Bl\left(\frac{\delta x}{\delta t}\right) \Longrightarrow i = \frac{E - Bl\left(\frac{\delta x}{\delta t}\right)}{R}$$

The above expression shows that the e.m.f. of the battery 'E' of the circuit is opposed by an induced e.m.f., viz., 'e' equal to $Bl\left(\frac{\delta x}{\delta t}\right)$ due to the motion of the rod PQ in magnetic field 'B'.

$$\text{Thus, } e = -Bl\left(\frac{\delta x}{\delta t}\right)$$

As, l δx is change in area of the circuit, B l δx denotes the change in the magnetic induction 'B' and $Bl\left(\frac{\delta x}{\delta t}\right)$ denotes the rate of change of magnetic induction. If Φ_B denotes magnetic induction,

Induced e.m.f. $e = -\frac{\partial \Phi_B}{\partial t}$, therefore, induced e.m.f., $e = -\frac{d\Phi_B}{dt} = -\frac{BA}{dt} = -\frac{Bldx}{dt} \Longrightarrow e = -Blv$

This expression gives an expression for induced e.m.f.

Questions

1. Derive an expression for induce e.m.f.

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2. State and explain the term electromotive force
3. What is electromagnetic induction? Derive an expression for induced e.m.f.
4. Derive an expression for the motional e.m.f induced by the motion of a conductor in a uniform magnetic field.

References:

1. Unified Physics, Volume III, Jai Prakash Nath Publications, Meerut

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