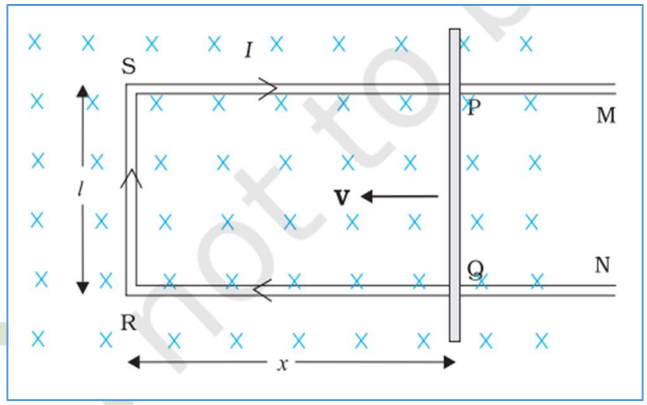
Motional Electromotive Force (Motional EMF):

Let us consider a straight conductor moving in a uniform magnetic field. Figure shows a rectangular conductor **PQRS** in which the conductor **PQ** is free to move. The rod **PQ** is moved towards the left with a constant velocity $\boldsymbol{v}$ as shown in the figure. Assume that there is no loss of energy due to friction. PQRS forms a closed circuit enclosing an area that changes as PQ moves. It is placed in a uniform magnetic field B which is perpendicular to the plane of this system.



If the length $RQ = x$ and $RS = l$, the magnetic flux $\emptyset_B$ enclosed by the loop PQRS will be,

$$\emptyset_B = BA\cos\theta$$
$$or, \emptyset_B = BA \qquad (\theta = 0^0)$$
$$or, \emptyset_B = Blx ------(1) \qquad (A = lx)$$

Since x is changing with time, the rate of change of flux $\emptyset_B$ will induce an emf given by:

$$\varepsilon = -\frac{d\emptyset_B}{dt}$$
$$or, \varepsilon = -\frac{d(Blx)}{dt}$$
$$or, \varepsilon = -Bl\frac{dx}{dt}$$
$$or, \varepsilon = -Blv$$
$$|\boldsymbol{\varepsilon}| = \boldsymbol{Blv} ------(\mathbf{2})$$

Equation (2) gives the required motional emf.

In vector form: $$\vec{\boldsymbol{\varepsilon}} = \boldsymbol{l}(\vec{\boldsymbol{v}} \times \vec{\boldsymbol{B}})$$

The direction of current is from **P** to **Q** in straight conductor and **Q** to **P** in external circuit.

- We can induce emf by moving a conductor instead of varying the magnetic field, that is, by changing the magnetic flux enclosed by the circuit.
- This gives the expression for induced emf developed in the conductor moving in the uniform magnetic field. Since it is due to the motion of conductor through the magnetic field, it is called **motional emf**.
- The induced emf is constant if v is constant. Hence the emf in eq. (2) is a type direct-current. It's not a very practical device because the rod eventually moves beyond the U-shaped conductor and loses contact, after which the current stops.

The general form of Motional EMF:

We can generalize the concept of motional emf for a conductor with any shape, moving in any magnetic field, uniform or not,

For any closed conducting loop, the total emf is,

$$\boldsymbol{\varepsilon} = \oint (\vec{\boldsymbol{v}} \times \vec{\boldsymbol{B}}).\vec{\boldsymbol{dl}}$$