# 1.2 STATICALLY AND DYNAMICALLY INDUCED EMF

## Dynamically induced EMF

Figure 1.7 shows three conductors *a, b, c* moving in a magnetic field of flux density *B* in the directions indicated by arrow. Conductor *a* is moving in a direction perpendicular to its length and perpendicular to the flux lines. Therefore it cuts the lines of force and a motional emf is induced in it. Let the conductor move by a distance *dx* in a time *dt*. If the length of conductor is *l*, the area swept by the conductor is *l dx*. Then change in flux linking the coil

Since there is only one conductor = dϕ = Bldx

$$e = \frac{d\phi}{dt} = \frac{Bldx}{dt}$$

Since dx/dt is v, i.e velocity of conductor,

$$e = Blv \text{ volts}$$

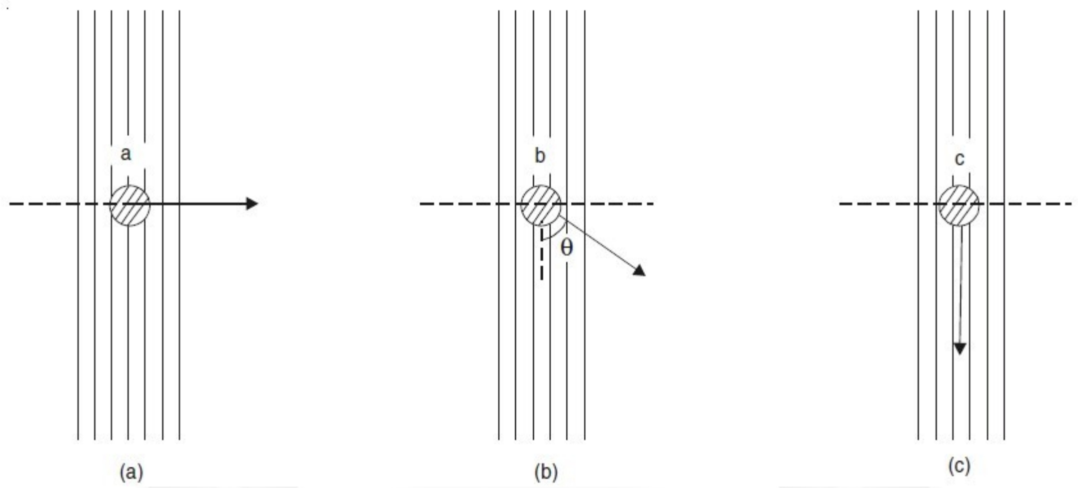


**Figure 1.3.1 Motion of a conductor in a magnetic field**

*[Source: "Electric Machinery Fundamentals" by* Stephen J. Chapman*, Page: 59]*

where

*e* = emf induced, volts

*B* = flux density, tesla

*v* = velocity of conductor, metres/second

*l* = length of conductor, metres

The motion of conductor *b* (Fig. 1.7*b*) is at an angle θ to the direction of the field. If the conductor moves by a distance *dx*, the component of distance travelled at right angles to the field is (*dx* sin θ) and, proceeding as above, the induced emf is

$$E = Blv \sin\theta \text{ volts}$$

The force *F* on a particle of charge *Q* moving with a velocity *v* in a magnetic field B is

$$F = Q\left(v \times B\right) \quad N$$

Dividing *F* by *Q* we get the force per unit charge, *i.e.* electric field *E*, as

$$E = \frac{F}{Q} = v \times B \quad \text{volts/m}$$

The electric field *E* is in a direction normal to the plane containing *v* and *B*. If the charged particle is one of the many electrons in a conductor moving across the magnetic field, the emf *e* between the end points of conductor is line integral of electric field *E*, or

$$e = \oint E \cdot dl = \oint (v \times B) \cdot dl$$

where

*e* = emf induced, volts

*E* = electric field, volts/m

*dl* = elemental length of conductor, *m*

*v* = velocity of conductor, metres/second

*B* = flux density, tesla.

**Statically induced emf (or Transformer emf)**

Statically induced emf (also known as transformer emf) is induced by variation of flux. It may be (*a*) mutually induced or (*b*) self induced.A mutually induced emf is set up in a coil whenever the flux produced by a neighbouring coil changes. However, if a single coil carries alternating current, its flux will follow the changes in the current. This change in flux will induce an emf known as self-induced emf in the coil, the word 'self' signifying that it is induced due to a change in its own current. The magnitude of statically induced emf. It is also known as transformer emf, since it is induced in the windings of a transformer. The total flux linkages λ of a coil is equal to the integral of the normal component of flux density *B* over the surface bounded by the coil, or

The surface over which the integration is carried out is the surface bounded by the periphery of the coil. Thus, induced emf

$$\lambda = \iint B \cdot ds$$

$$e = \frac{d\lambda}{dt} = \frac{d}{dt}\iint B \cdot ds$$

$$e = \frac{d}{dt}\int_s B \cdot ds$$

When the coil is stationary or fixed

$$e = \int_s \frac{\partial B}{\partial t} \cdot ds$$

where

$e$ = emf induced, volts

$B$ = flux density, tesla

$ds$ = element of area, $m^2$

$t$ = time, seconds.