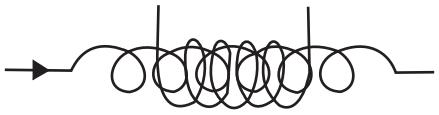
Then $M = k\sqrt{L_1 L_2}$ where k is coupling factor and $k \leq 1$. $k = 1$ if coils are wound one over the other.

If N_1 are number of turns per unit length in primary coil and N_2 are total number of tuns in secondary, then in Fig.



Mutual inductance

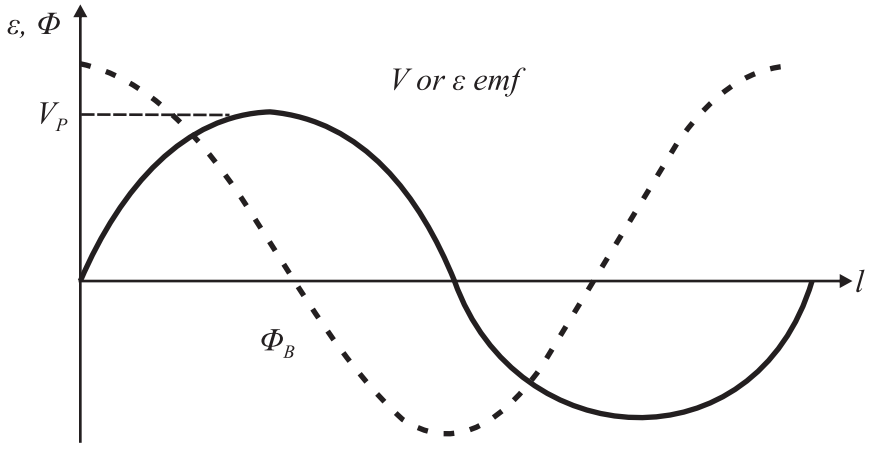
$M = \mu_0 n_1 N_2 A = \mu_0 n_1 n_2 Al$ where l is length of secondary coil. If a core of relative permeability μ_r is introduced then

$$M = \mu_0 \mu_r n_1 n_2 Al. \text{ Here } n_2 = \frac{N_2}{l}$$

B 5. **Energy stored** in an inductor $U = \frac{Li^2}{2}$ and energy is in the form of magnetic energy.

B 6. **AC generator** $emf\ \varepsilon = N\omega BA_0 \sin \omega t$ where N is number of turns and A_0 is maximum area and ω is angular frequency.
Note $V_P = N\omega BA_0$ is peak voltage. In AC generator slip rings are used.

In *DC* generator the scheme is same, however, in place of slip rings, split rings are used so that after each half cycle the direction of emf reverses.



Magnetic flux φ and voltage V in a AC generator

C 1. A magnetic field of flux density 10 T acts normal to coil of 50 turns having 100 cm^2 area. Find E.M.F. induced if the coil is removed from the magnetic field in 0.1 sec.

Solution

Here

$B = 10T, N = 50 \qquad A = 100cm^2 = 10^{-2}\ m^2. \qquad dt = 0.1\ s$

When the coil is in the magnetic field, flux linked with it is

$$\Phi_1 = NBA\cos\theta = NBA \quad (\cos\theta = \cos 0^o = 1) = 50 \times 10 \times 10^{-2} = 5Wb$$

When the coil is removed from the magnetic field, $B = 0$

So flux linked with it is, $\Phi_2 = 0$

Induced e. m. f. is given by $\varepsilon = -\dfrac{(\Phi_2 - \Phi_1)}{dt} = -\dfrac{(0 - 5)}{0.1} = 50$ volt

C 2. A iron rod of length of 1m fixed at one end is rotated with angular velocity 200 rad s^{-1} about the fixed end in a magnetic field of 0.2 T. Find the induced *e . m. f.* between the centre and far end of the rod.

Solution

Here

$l = 1m, B = 0.2T, \qquad \omega = 200\ rad\ s^{-1}$

Using $\varepsilon = \dfrac{1}{2}B\omega l^2$, *we get* $\varepsilon = \dfrac{0.2 \times 200 \times 1}{2} = 20V$

C3. A conducting wire of 100 turns is wound over and near the centre of a solenoid of 100 cm length and 2 cm radius having 600 turns. Calculate the mutual inductance of the two coils.

Solution

Here

$N_1 = 600, N_2 = 100, \quad l = 100cm = 1m \qquad r = 2\ cm = 2 \times 10^{-2}m. \qquad \therefore A = \pi r^2 = 3.14 \times 4 \times 10^{-4}\ m^2.$

Using $\mathbf{M = \dfrac{\mu_0 N_1 N_2 A}{l}}$ **we have**

$$\mathbf{M} = \frac{4\pi \times 10^{-7} \times 600 \times 100 \times 3.14 \times 4\ 10^{-4}}{1} = 4 \times 3.14 \times 10^{-7} \times 600 \times 100 \times 3.4 \times 4 \times 10^{-4}$$

$$= 946.5 \times 10^{-7} = 9.47 \times 10^{-5} H$$

C4. Magnetic flux of 20 μ Wb is linked with a coil when current of 5 mA is flown through it. What is the self inductance of the coil ?

Solution.

Here $\Phi_B = 20\mu\ Wb = 20 \times 10^{-6}$

$I = 5mA = 5 \times 10^{-3} A$

Using $\Phi_B = LI$, we get $L = \dfrac{\Phi_B}{I} = \dfrac{20 \times 10^{-6}}{5 \times 10^{-3}} = 4 \times 10^{-3}\ H = 4\ mH$

C5. A rectangular coil of dimensions 0.10 m x 0.05 m, consisting of 1000 turns rotates about an axis parallel to its long side making 3600 rpm. Find the instantaneous value of the e.m.f. induced with the coil at 30^0 to the field of magnitude 100 gauss.

Solution.

Here $A = 0.10\ m \times 0.05\ m = 5 \times 10^{-4}\ m^2 \qquad n = 1000 \quad \upsilon = 3600\ rpm = \dfrac{3600}{60}\ 60rpm$

$\omega = 2\pi\upsilon = 2\ 3.14 \times 60 = 376.8\ rads^{-1}$

Now, $\varepsilon = nBA\omega \sin 0 = 1000 \times 100 \times 5 \times 10^{-4} \times 376.8 = 0.942V.$