* Motional EMF:
  
  - $\mathcal{E} = BV_L$ [due to accumulation of charge at one side].
  - At steady state of magnetic and electric force, $E = nB$.
  - $\mathcal{E} = \frac{BV_L}{R + r}$ [R → resistance of external wire, r → resistance of moving conductor].

  - When $\vec{v}$ & $\vec{B}$ make angle $\theta$,
    
    $\mathcal{E} = BLv \sin \theta$.

  - When length of conductor is parallel either to the direction of $\vec{v}$ or $\vec{B}$, no potential difference is created.

* Fleming's Right Hand Rule:

  Thumb --- Pole Finger --- Middle Finger (All at right angle)

  --- Motion of --- B field --- direction of
  conductor            induced emf.

* Work to be done to move a conductor in a magnetic field: $W = BILv + (B, dL \text{ at right angle})$

* Rate of flux cutting by conductor is

  $\mathcal{E} = -\frac{d\Phi_m}{dt} = BV_L$. 
* Induced Electric Field:

\[ \mathcal{E} = \oint_{c} \mathbf{E} \cdot d\mathbf{r} = -\frac{d\Phi_{m}}{dt} \]

Electric field induced by changing magnetic field is non-electrostatic & non-conservative in nature. Field lines of such a field are closed lines.

* Self-Induction: Whenever the current flowing through an electric circuit is charged or a circuit is switched on or switched off, an emf is induced in the circuit opposing the change. This phenomenon is called self-induction.

\[ N\Phi_{m} \propto I \implies N\Phi_{m} = LI \quad [L \rightarrow \text{Inductance}] \]

\[ N \text{ turns in coil} \]

\[ \mathcal{G} = -N \frac{d\Phi_{m}}{dt} = -L \frac{dI}{dt} \]

- Unit of self-inductance: Henry (H).

- \([L] = [ML^{2}T^{-2}A^{-2}]\).

* Work done to establish a current in an electric circuit:

\[ W = \frac{1}{2} LI^{2} \]

- Energy stored in the magnetic field

\[ \text{here} = U = \frac{1}{2} LI^{2} \]
1. Self inductance of a plane coil:
\[ L = \frac{\mu_0 N^2 A}{2} \]

2. Self inductance of a long solenoid:
\[ L = \mu_0 n^2 A r^2 \]

3. Self inductance of a toroid:
\[ L = 2\mu_0 T n^2 A \] [Area of cross section]

* Energy density in magnetic field:
Energy per unit volume of the magnetic field is

\[ u_m = \frac{B^2}{2\mu_0} \] \[ u_e = \frac{1}{2} \varepsilon_0 E^2 \]

* Mutual Induction: If two coils are placed coaxially or at a position where one coil's magnetic field lines pass through another coil, then any change in current in one produces an induced emf in the other. This is called mutual induction.

\[ N_2 \phi_m = NI \]
\[ N_1 \phi_m' = N'I' \]

\[ H = M' \]
EM Induction

1. Mutual Inductance of two coils:
   - Two long coaxial solenoids:
     \[ M_{12} = M_{21} = M = \mu_0 n_1 n_2 A \alpha \]
     \[ n \to \text{no. of turns/length} \]

2. Two coaxial coils of unequal sizes:
   \[ M = \frac{\mu_0 T C_1 N_1 N_2 \alpha^2}{2p_1} \]
   \[ \text{coefficient of coupling, } K = \sqrt{\frac{M}{L_1 L_2}} \]

Combination of Inductors:

1. Series:
   \[ L_{eq} = \sum_{i=1}^{n} L_i \]

2. Parallel:
   \[ \frac{1}{L_{eq}} = \sum_{i=1}^{n} \frac{1}{L_i} \]

3. Two nearby coils in series:
   \[ L = L_1 + L_2 + 2M \]
   When fluxes for own current by others \( \Phi \) are opposite in direction,
   \[ L = L_1 + L_2 - 2M \]
Eddy Currents: When metal sheet enters or goes out from a magnetic field or through the metal sheet, magnetic field is changing with time, induced currents are created and they circulate throughout the volume of the material. This is called Eddy Current.