As we know in physics, potential energy is stored energy of an object. Similar, in electrostatic, a charge displays against electric field from one position to another position then the charge will store some energy i.e., **Electric Potential a**nd the maximum capacity to store energy in the form of charge is referred as **Capacitance.**

Formulae:

Electric Potential:

- If a point charge is brought from position A to B against electric field **E,** then potential energy would be:

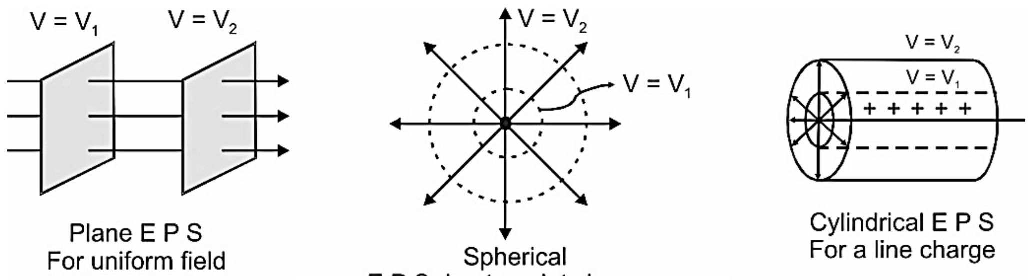
$$\Delta U = U_A - U_B = W_{AB} = -\int_A^B F_{ext}.dr$$

- Work done by external force to bring a positive point charge **q** from point A to point B:

$$W = V_B - V_A = \frac{U_B - U_A}{q}$$, V_B and V_A are electric potential.

- Potential due to point charge: $V = \frac{kq}{r}$
- Potential Energy between two charges: $U = k\frac{q_1 q_2}{r_{12}}$
- Potential due to system of charges: $V = k(\frac{q_1}{r_{1p}} + \frac{q_2}{r_{2p}} + + ... + \frac{q_n}{r_{np}})$
- Potential Energy due the system of three charge particles: $U = k(\frac{q_1 q_2}{r_{12}} + \frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}})$
- Equipotential Surfaces: It is the surface where potential is constant at all points on the surface. For a single charge the potential will be $V = \frac{1}{4\pi\varepsilon_o}\frac{Q}{R}$

Electric Potential and Capacitance



EPS= Electrostatic Potential Surface

Relation between electric field and potential: $E = -\frac{dV}{dr}$

Potential due to dipole: $V = \frac{kP\cos\theta}{r^2}$

- In vector form: $V = k\frac{P.\hat{r}}{r^2}$ when r>>a
- Potential on the dipole axis is given by (which means $\theta = 0 \text{ or } \pi$): $V = \pm\frac{kp}{r^2}$
- Potential energy of dipole in external electric field: $U = -\vec{p}.\vec{E} = -pE\cos\theta$

Dielectrics and Polarization: Dielectrics are non-conducting substances, the dipole moment per unit volume is called **polarization** and is denoted by P. Hence, $P = \varepsilon_o \chi_e E$. where χ_e is a constant dielectric property and is known as the dielectric medium's electric susceptibility.

Capacitance: When V is proportional to charge Q in the region between charged surfaces.

$$Q \propto V$$
$$C = \frac{Q}{V}$$

Where, C= constant of proportionality and it's called as **capacitance.**

- Parallel plate capacitance:

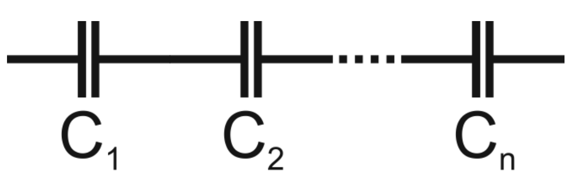
  $C = \varepsilon_o \frac{A}{d}$, A= Area of plate and d= distance between plates

  For A=1 m^2 and d=1m, C= 8.85 x 10^{-12} F
- In case of thickness t of **dielectric** : $C = \varepsilon_o \frac{A}{d - t + \frac{t}{k}}$, and

  K= dielectric constant
- Energy density in Electric Field: $U = \frac{\varepsilon_o E^2}{2}$
- Energy of capacitor: $U = \frac{1}{2}CV^2$

Combination of capacitor:

- Capacitor in series: $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots\ldots + \frac{1}{C_n}$



- Combination in parallel: $C_{eq} = C_1 + C_2 + C_3 + C_4 + \ldots\ldots C_n$