Class : 12th Physics
Chapter- 2 : Electrostatic Potential and Capacitance

Electrostatic Potential and Capacitance

Electric Potential

Work done per unit test charge by an external agent in moving the test charge from reference point to the desired point S.I. unit J/C

V_0 = Work done/charge

Electric potential due to a point charge

$$V = \frac{1}{4\pi\varepsilon_0}\sum \frac{Q_i}{r_i}$$

Potential due to a system of charges

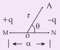
$$V_P = Q/4\pi\varepsilon_0 r$$

Potential due to a dipole

$$V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2}$$

Where p = qd

θ = ∠AON



At θ = 0, $V = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$ [axial position]

At, θ = 90°, V = 0 [equitorial position]

Capacitance, $C = \frac{Q}{V}$

Capacitance of a parallel plate capacitor

$C = K\,\varepsilon_0 A/d$, K = dielectric constant

Capacitance when material slab inserted between them

$C = K\varepsilon_0 A/[Kd - x(K-1)]$

where x = thickness of the slab inserted

Parallel grouping of capacitors

$C = C_1 + C_2 + C_3 + \dots + C_n$

for two, $C = C_1 + C_2$

Capacitance of a spherical capacitor

$$C = 4\pi\varepsilon_0 \Big/ \left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

For isolated sphere

$C = 4\pi\varepsilon_0 R$

Energy stored in a capacitor

$$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C}$$

Series grouping of capacitors

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots + \frac{1}{C_n}$$

For two, $C = \frac{C_1 C_2}{C_1 + C_2}$

Dielectric

Conductors	Insulators
Such a material Which when placed in an electric field, the free electrons move in a direction opposite to the field.	Such a material in which electrons are tightly bound, & when exposed in an electric field, Electrons does not move *i.e.* having no free electrons

- Electric field inside a conductor is zero
- Electric field is always perpendicular to the charged surface
- In static state, there will be no additional charge in a conductor

- $F = \frac{q_1 q_2}{4\pi K\varepsilon_0 r^2}$, K = dielectric constant of medium
- A dielectric is an electrical insulator that can be polarized by an applied electric field.

Equipotential Surface

- Potential is same at all the points of the surface
- Component of electric field parallel to an equipotential surface is zero.

Electric Potential Energy

- It is negative of work done by the electric force as the configuration of the system changes.
- $$U_{r_2} - U_{r_1} = -W = \frac{q_1 \cdot q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$$
- If the separation between charges is 'r' then $U_{(r)} = \frac{q_1 q_2}{4\pi\varepsilon r}$
- Potential Difference,

$$V_B - V_A = \frac{U_B - U_A}{q}$$

$U_B - U_A$ = change in Potential Energy

q = test charge

Potential Energy of a dipole

dU = pE sinθdθ

If we choose P.E. of dipole to be zero when θ = 90° then

$$U_\theta - U_{90°} = \int_{90°}^{\theta} pE\sin\theta\, d\theta$$

$U_\theta = -pE\cos\theta = -\vec{p}\times\vec{E}$

If it is rotated through angle θ against the torque