Class XII
Physics
Ch 2: Electrostatic Potential and capacitance

Chapter Notes

Top Concepts

1. Potential at a point is the work done by per unit charge by an external agency, in bringing a charge from infinity to that point.

2. Equipotential surface:
Definition: An equipotential surface is a surface over which potential has a constant value.
Imp:
a. For a point charge, concentric spheres centered at a location of the charge are equipotential surfaces.
b. The electric field E at a point is perpendicular to the equipotential surface through the point.
c. E is in the direction of the steepest decrease of potential.

3. Electric field E along the outward normal to the surface is zero and σ is the surface charge density. Charges in a conductor can reside only at its surface. Potential is constant within and on the surface of a conductor.
In a cavity within a conductor (with no charges), the electric field is zero.

4. Capacitance is determined purely geometrically, by the shapes, sizes, and relative positions of the two conductors.

5. Changes observed when the medium between the plates of a capacitor is filled with an insulating substance (dielectric).
i. polarization of the medium gives rise to a field in the opposite direction. The net electric field inside the insulating medium is reduced.
ii. potential difference between the plates is thus reduced.

iii. capacitance C increases from its value C_0 when there is no medium (vacuum).

$C = KC_0$

where K is the dielectric constant of the insulating substance.

6. A conductor has a cavity with no charge inside the cavity, then $\vec{E} = 0$ inside, no matter what happens outside the conductor.

Therefore, even if there are intense electric fields outside the conductor, the cavity inside has $\vec{E} = 0$, shielding whatever is inside the cavity from whatever is outside the cavity. This is called electrostatic shielding.

Top Formulae

1. Potential due to a charge at a point is given by

$$V(r) = \frac{2}{4\pi\varepsilon_0}\frac{Q}{r}$$

2. The electrostatic potential at a point with position vector r due to a point dipole of dipole moment p place at the origin is

$$V(r) = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}.\vec{r}}{r^2}$$

The result is true also for a dipole (with charges –q and q separated by 2a) for r >> a.

3. For a charge configuration q_1, q_2, …… q_n with position vectors r_1, r_2, ….r_n, the potential at a point P is given by the superposition principle

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_{1p}} + \frac{q_2}{r_{2p}} + \dots + \frac{q_n}{r_{np}}\right)$$

where r_{1p} is the distance between q_1, and P, as and so on.

4. Potential energy stored in a system of charges is the work done (by an external agency) in assembling the charges at their locations. Potential energy of two charges q_1, q_2, at r_1, r_2 is given by

$$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$$

where r_{12} is distance between q_1 and q_2

5. PE of a charge q in an external potential, V(r)= qV(r).

PE of a dipole of dipole moment p in a uniform electric field E = −p.E.

6. Capacitance C of a system of two conductors separated by an insulator is defined by C = Q/ V

where Q and – Q are the charges on the two conductors

V is the potential difference between them.

7. Capacitance C of a parallel plate capacitor (with vacuum between the plates) is given by

$$C = \varepsilon_0 \frac{A}{d}$$

where A is the area of each plate and d the separation between them.

8. For capacitors in the series combination, the total capacitance C is given by:

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

For capacitors in the parallel combination, the total capacitance C is given by:

$$C = C_1 + C_2 + C_3 + \ldots\ldots$$

where C_1, C_2, C_3... are individual capacitances

9. The energy U stored in a capacitor of capacitance C, with charge Q and voltage V is

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

The electric energy density (energy per unit volume) in a region with electric field is (1/2) $\varepsilon_0 E^2$

10. The potential difference between the conductor (radius r_o) inside & outside spherical shell (radius R) is

$\phi(r_0) - \phi(R) = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r_0} - \frac{1}{R}\right)$, which is always positive.