ELECTROSTATIC POTENTIAL AND CAPACITANCE

POTENTIAL DUE TO A POINT CHARGE

Electric potential:

Electric potential is a scalar property of every point in the region of electric field. At a point in electric field, electric potential is defined as the interaction energy of a unit positive charge.

If at a point in electric field a charge q0 has potential energy U, then electric potential at that point can be given as

$$V = \frac{U}{q_0} \text{ Joule/coulomb}$$

As potential energy of a charge in electric field is defined as work done in bringing the charge from infinity to the given point in electric field. Similarly, we can define electric potential as "work done in bringing a unit positive charge from infinity to the given point against the electric forces."

Properties:

1. Potential is a scalar quantity, its value may be positive, negative or zero.
2. S.I. Unit of potential is volt = joule/ coulomb and its dimensional formula is $[M^1L^2T^{-3}I^{-1}]$.
3. Electric potential at a point is also equal to the negative of the work done by the electric field in taking the point charge from reference point (i.e. infinity) to that point.
4. Electric potential due to a positive charge is always positive and due to negative charge, it is always negative except at infinity. (Taking $V_\infty = 0$)
5. Potential decreases in the direction of electric field.

Electric Potential due to a Point Charge in its Surrounding:

We know the region surrounding a charge is electric field. Thus, we can also define electric potential in the surrounding of a point charge.

The potential at a point P at a distance x from the charge q can be given as

$$V_P = \frac{U}{q_0}$$

Where U is the potential energy of charge q_0 , if placed at point P, which can be given as

$$U = \frac{Kqq_0}{X}$$

Thus, potential at point P is

$$V_P = \frac{Kq}{X}$$

The above result is valid only for electric potential in the surrounding of a point charge. If we wish to find electric potential in the surrounding of a charged extended body, we first find the potential due to an elemental charge dq on body by using the above result and then integrate the expression for the whole body.

Charge	Electric field at a distance r	Electric potential at a distance r
Point charge +q	$\frac{q}{4\pi\varepsilon_0 r^2}\hat{r}$	$\frac{q}{4\pi\varepsilon_0 r}$
Point charge –q	$\frac{(-q)}{4\pi\varepsilon_0 r^2}\hat{r}$	$\frac{(-q)}{4\pi\varepsilon_0 r}$