4. Equipotential Surface

1. **Definition of *Equipotential Surface*:**

A surface having the same potential at every point on it is called an *Equipotential Surface*.

Examples: Equatorial plane of a dipole, spherical surfaces having a point charge at its centre, parallel planes perpendicular to the uniform field are equipotential surfaces.

2. **Electric field is perpendicular to an equipotential surface:**

Since every point on an equipotential surface is at the same potential, the work done in displacing a charge from one point to another on the surface is zero. Therefore, work done by the electric field in an elementary displacement of unit charge on the surface will be:

$$\Rightarrow dW = \vec{E} \cdot d\vec{r} = 0$$

This is possible only when angle between field vector and surface = 90°, that is, $\vec{E} \perp d\vec{r}$.

Hence, at every point field is perpendicular to the surface.
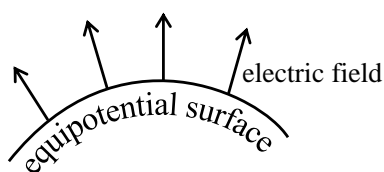
3. **Deduction of relation *E = −dV/dr* by the concept of equipotential surface:**

Supposed there are two equipotential surfaces *A* at *V* and *B* at potential *V + dV*. Two surfaces are too close with potential difference *dV* that electric field between them is supposed to be uniform.

Let the field be *E,* directed from *A* to *B*. The separation between the surfaces *A* and *B* is *dr* along the direction of field.
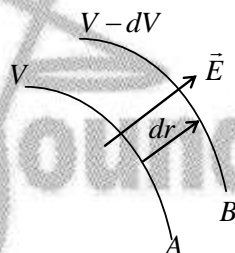
The work done by the field in moving a unit charge from *A* to *B,* along the direction of electric field will be: *dW = Edr.*
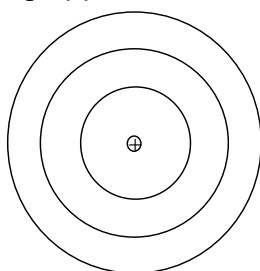
Since the change of potential is equal to the negative of work done, hence, *dV = − Edr.*
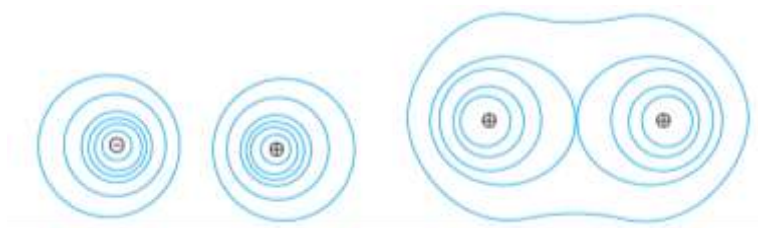
That is *E = − dV/dr.*

This is the required relation.

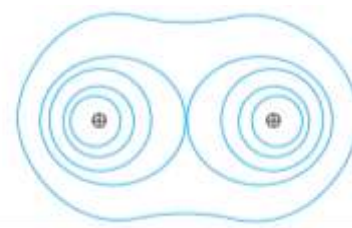4. **Example of Equipotential surfaces:**

for (i) point charge, (ii) a dipole, (iii) a system of two equal positive charges, (iv) an infinite line of charge, (v) a sheet of uniform charge. What is the shape of the equipotential surface of the dipole?
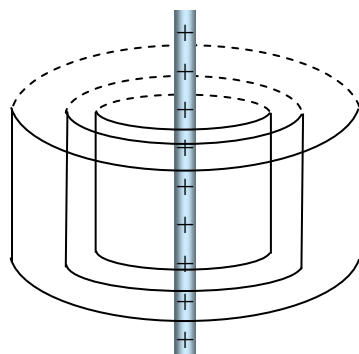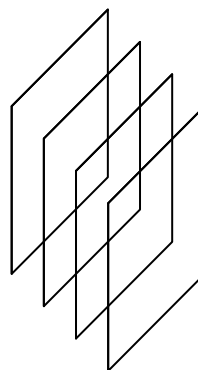

Point charge   Dipole   Two equal positive charges

Line of charge

Sheet of charge

field uniform

direction of field

equipotentials

field increasing in its direction

field lines parallel (field is in only one direction)

equipotentials

field decreasing in its direction

field increasing in its direction

field lines converging in its direction

equipotentials