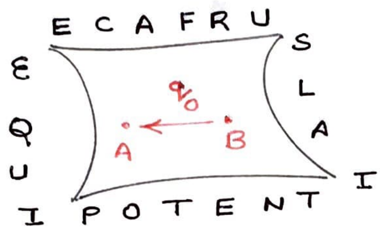
Equipotential Surfaces

Any surface over which the potential is constant is called an equipotential surface. In other words it is a surface inside an electric field over which all the points will be at same electric potential.

Properties:

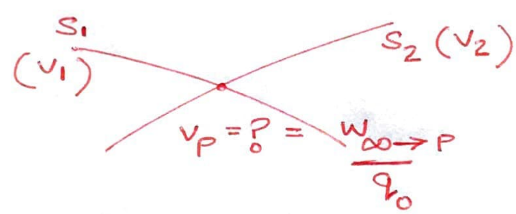
1) Electric potential difference b/w any two points of an equipotential surface is zero.

2) Work done to displace a test charge b/w any two points of an equipotential surface is zero.



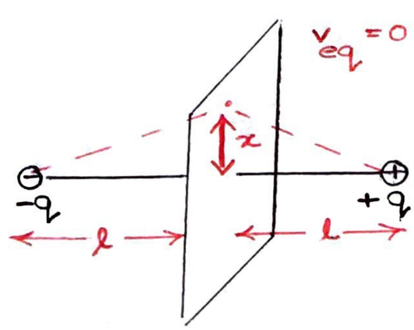
$$W_{B\to A} = q_0 \cdot \Delta V_{BA}$$
$$= q_0 \cdot (V_B - V_A)$$
as; $V_B = V_A$
$$\therefore W_{B\to A} = 0\ J$$

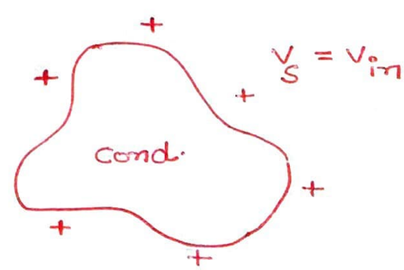
3) Equipotential surfaces do not intersect each other as more than [redacted] one values of electric potential is not possible at the same point.



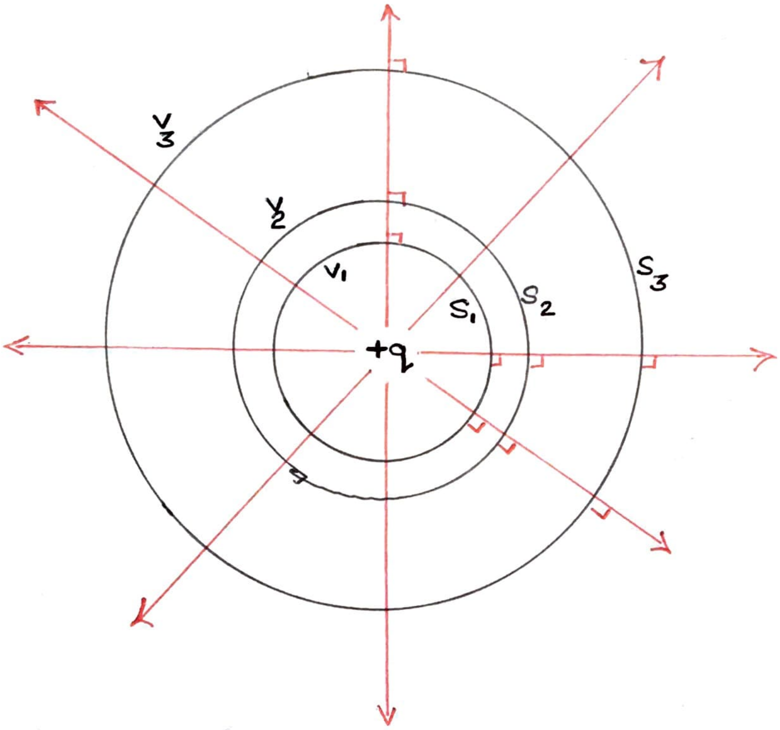
note; Electric field is conservative so work done to bring a test charge following any path to a point P will be unique, so potential at point P will not have more than one values.

4) Equitorial plane of a Dipole & a conductor are equipotentials.





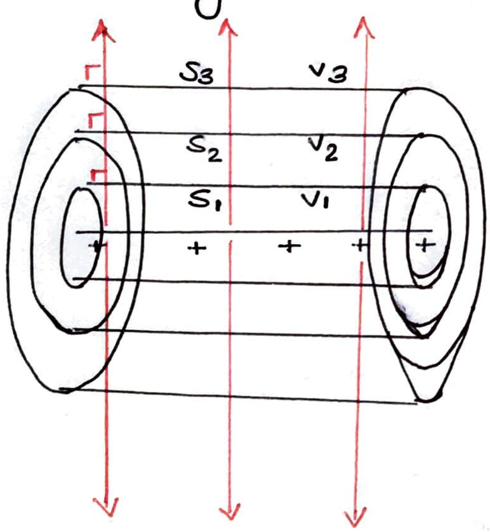
4) Electric field lines are always ⊥ to the equipotential surfaces. ie; Equipotential surfaces are planes '⊥' to the electric field lines.



i)

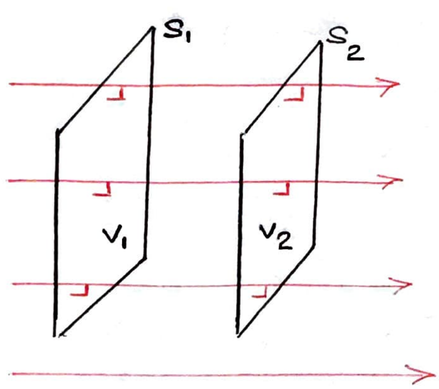
i) point charge ⇾ spherical equipotential surface

ii)



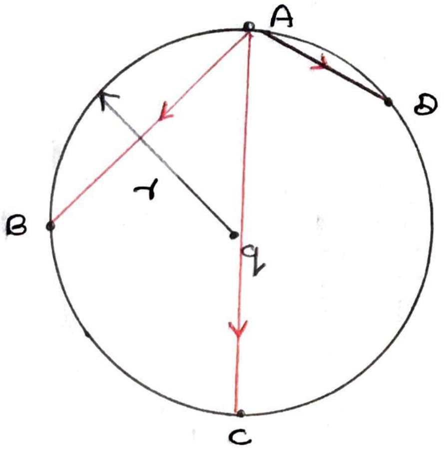
ii) Linear charge ⇾ cylindrical Equipotential surface

iii)



iii) ∞ charge ⇾ planar equipotential surfaces.

Eg: compare the work done to displace a test charge q_0 from point A to B, C & D.



i) $W_{AC} > W_{AB} > W_{AD}$

ii) $W_{AC} > W_{AB}$; $W_{AD} \to 0$

iii) $W_{AD} > W_{AB} > W_{AC}$

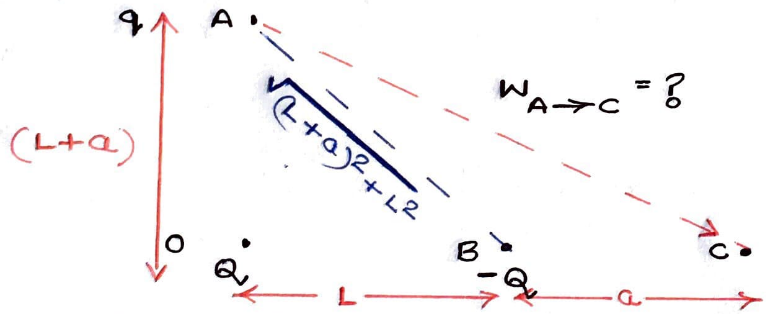
iv) $W_{AB} = W_{AC} = W_{AD} = 0$

Sol^n: → as $V_A = V_B = V_C = V_D = \frac{K \cdot Q}{r}$; so the given surface is an equipotential surface:

$$W_{\text{any path}} = q_0 \cdot \Delta V = 0$$

so $W_{AB} = W_{AC} = W_{AD} = 0.$

Eg: Calculate the work done required to Displace the charge 'q' from A to C.



point A & C lies on the equipotential surface of Q therefore no work has to be done against the electric field of Q.

work is only required against the charge -Q.

so $W_{A \to C} = q \cdot \Delta V_{CA} = q \cdot (V_C - V_A)$

$$= q \cdot \left[\left(-\frac{KQ}{a}\right) - \left(-\frac{KQ}{\sqrt{L^2 + (L+a)^2}}\right) \right]$$

$$\Rightarrow W_{A \to C} = KQ \cdot q \cdot \left[\frac{1}{\sqrt{L^2 + (L+a)^2}} - \frac{1}{a} \right] \text{J}$$