Equipotential surfaces

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 02
CHAPTER NAME : ELECTROSTATIC POTENTIAL AND CAPACITANCE

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LEARNING OUTCOME

- To establish the relation between electric potential and electric field.
- To understand the properties of equipotential surface.
- To understand equipotential surface for various charge systems.
- Students use concept of equipotential surface to visualize electric field.

REVIEW

- To use potential and potential difference to find the direction of flow of charges between two bodies in contact.
- To find the potential due to a dipole.
- Students use concept of potential for spherical shell.

RELATION BETWEEN ELECTRIC FIELD AND POTENTIAL

1.Electric field in a region can be determined from the electric potential by using relation,

$E = -\frac{dV}{dr}$

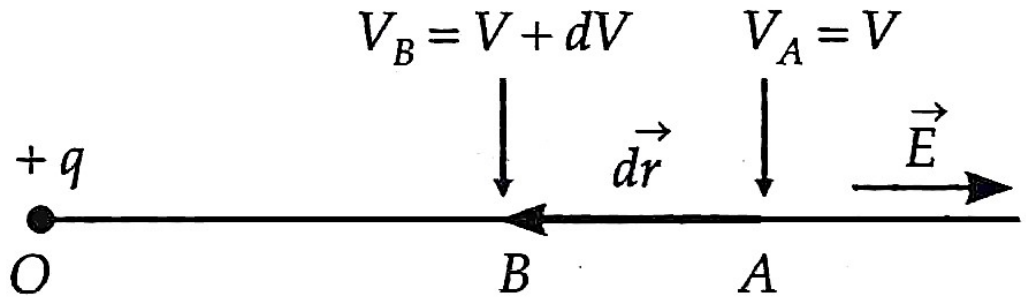
or $E_x = -\frac{\partial V}{\partial x}$, $E_y = -\frac{\partial V}{\partial y}$, $E_z = -\frac{\partial V}{\partial z}$

2.Electric field between two parallel conductors,

$E = \frac{V}{d}$

3. Electric potential in a region can be determined from the electric field by using the relation,

$V = - -\int_{\infty}^{r} \vec{E}\,.\,\vec{dr}$



POINTS TO REMEMBER

1. ➢(-ve) the sign indicates the direction of the electric field is in the direction of decreasing potential

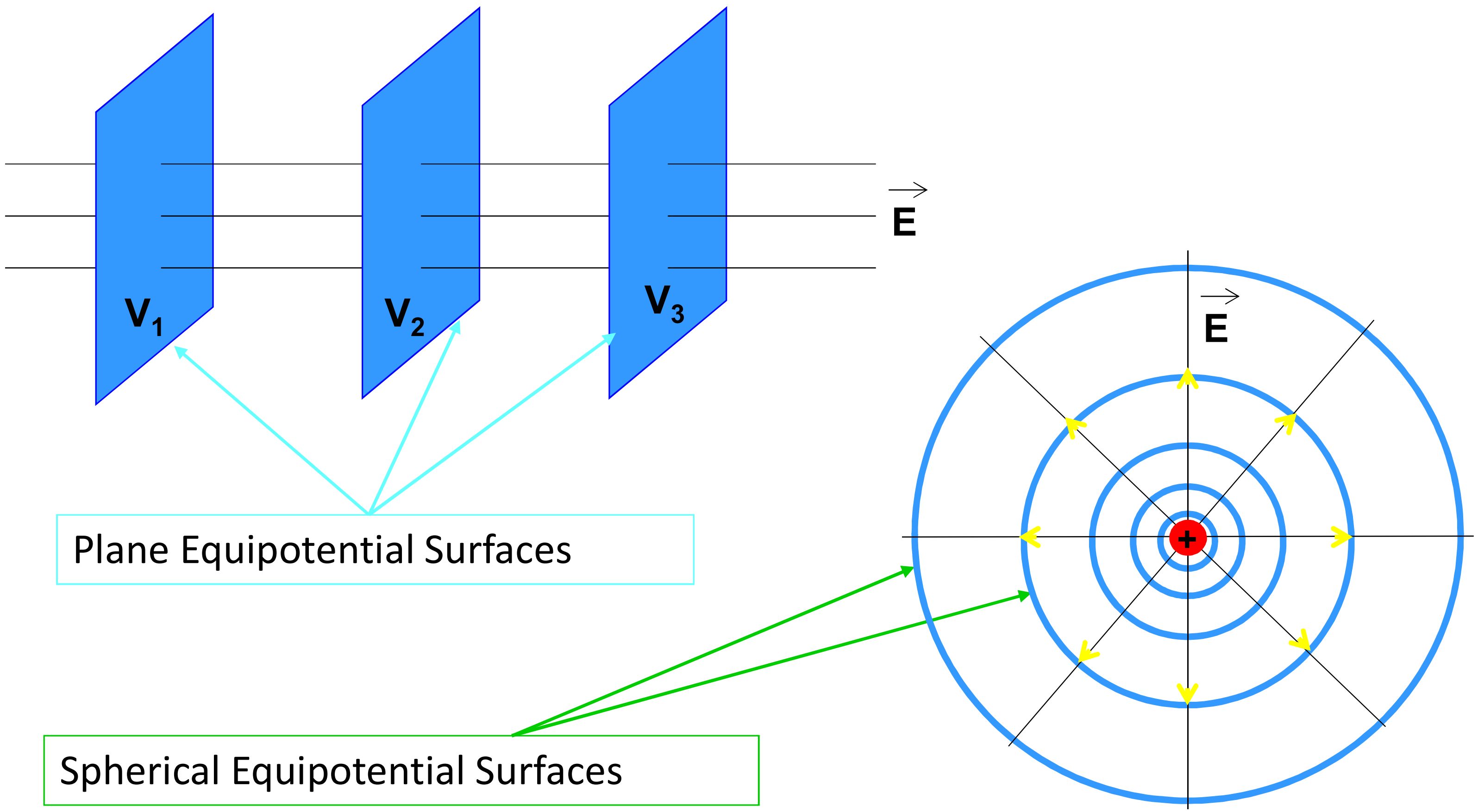
2. ➢The electric potential is a scalar whereas potential gradient is a vector quantity

3. For the uniform field, we can write $E = -\frac{\Delta V}{\Delta r} = \frac{-(V_2 - v_1)}{d}$
$V_1 - V_2 = Ed$

Equipotential Surfaces:

A surface at every point of which the potential due to charge distribution is the same is called equipotential surface.

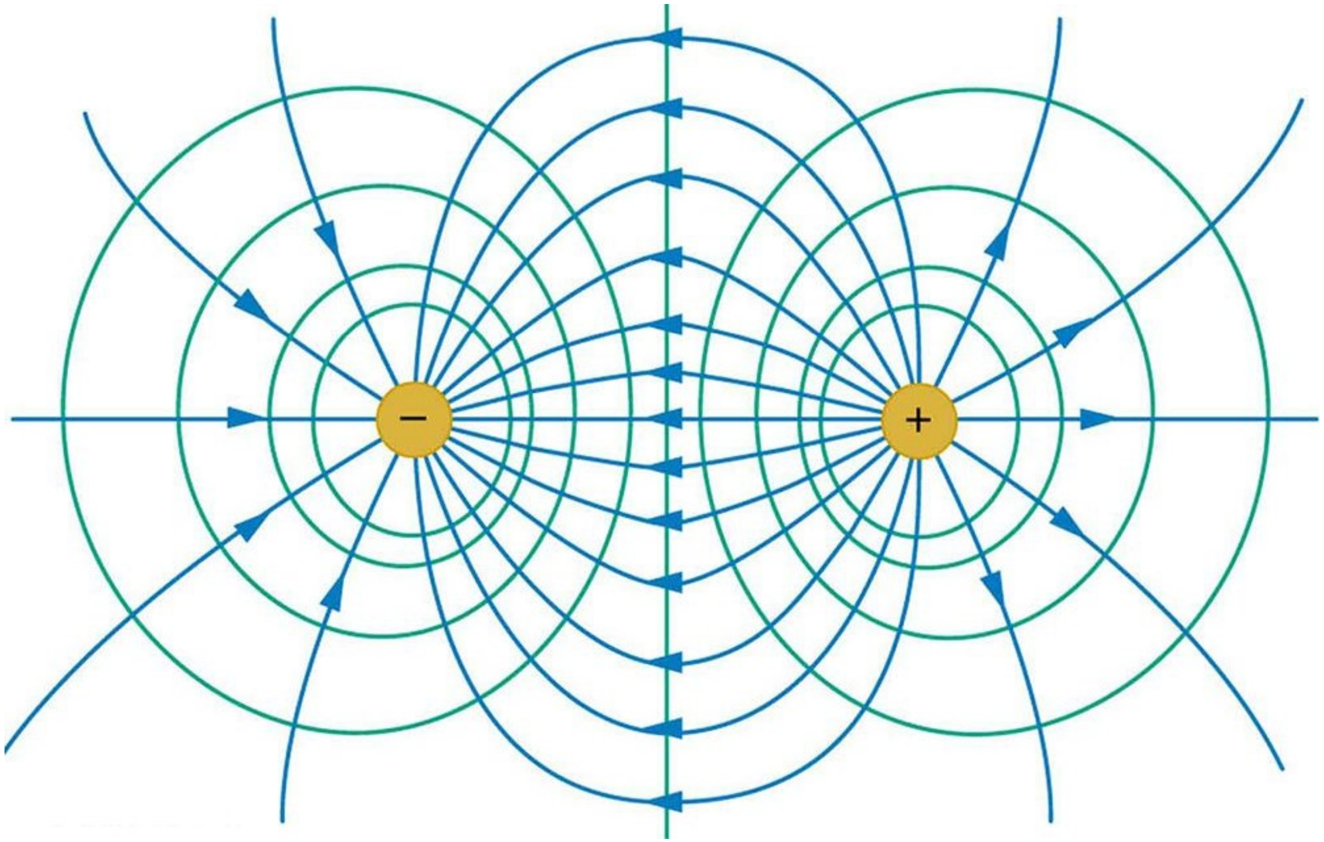
i) For a uniform electric field:



ii) For an isolated charge:

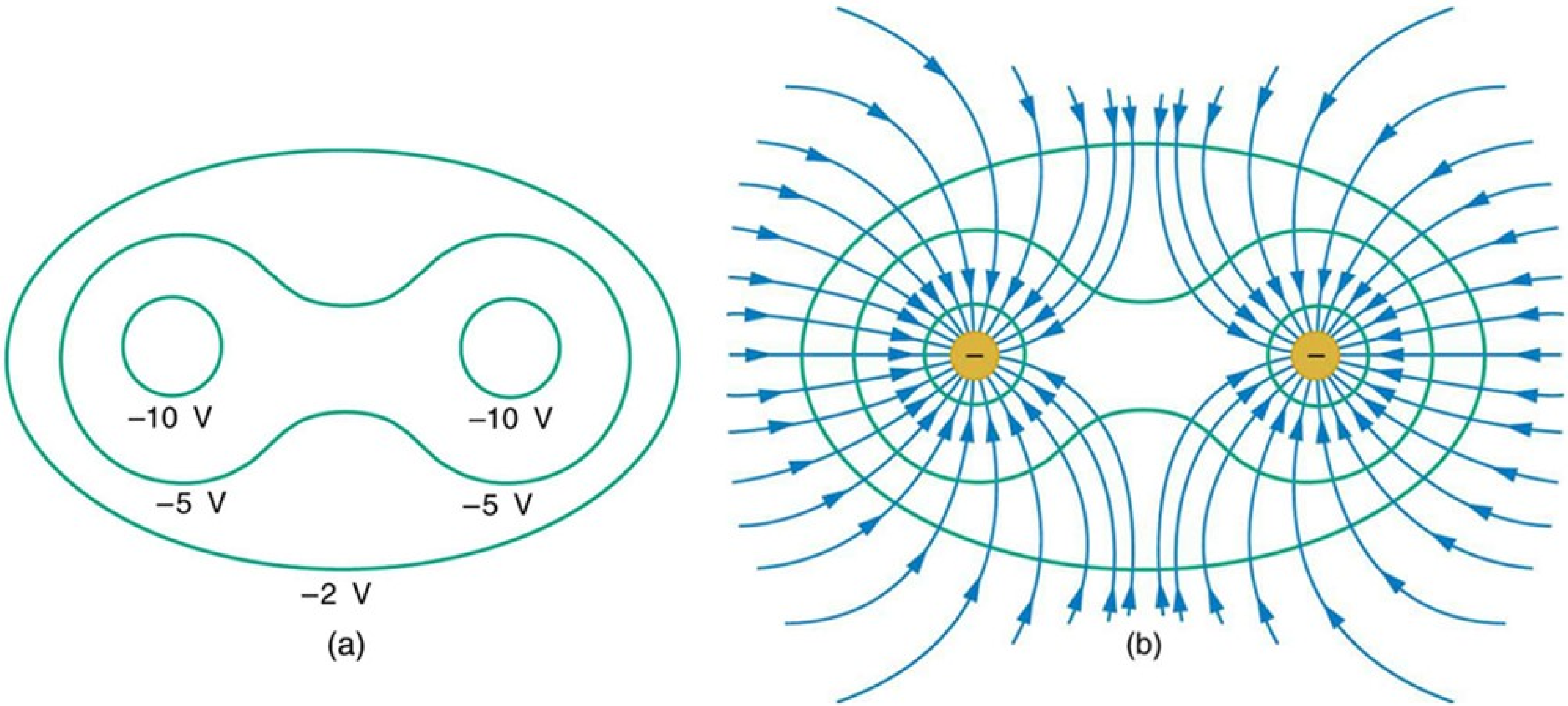
EQUIPOTENTIAL SURFACE

For Dipole:-



EQUIPOTENTIAL SURFACE

Two Identical Negative Charges:-



Properties of Equipotential Surfaces:

1. No work is done in moving a test charge from one point to another on an equipotential surface.

$$V_B - V_A = \Delta V = \frac{W_{AB}}{q_0}$$

If A and B are two points on the equipotential surface, then $V_B = V_A$.

$$\therefore \quad \frac{W_{AB}}{q_0} = 0 \qquad \text{or} \qquad W_{AB} = 0$$

2. The electric field is always perpendicular to the element dl of the equipotential surface.

Since no work is done on equipotential surface,

3. Equipotential surfaces indicate regions of strong or weak electric fields.

Electric field is defined as the negative potential gradient.

$$\therefore \quad E = -\frac{dV}{dr} \quad \text{or} \quad dr = -\frac{dV}{E}$$

4. Two equipotential surfaces can not intersect.

Note:

Electric potential is a scalar quantity whereas potential gradient is a vector quantity.

The negative sign of potential gradient shows that the rate of change of potential with distance is always against the electric field intensity.

PROPERTIES OF EQUIPOTENTIAL SURFACE

1. No work is done in moving the test charge over an equi-potential surface $W_{AB} = V_B - V_A = 0$
2. For any charge configuration, equipotential surface through a point is normal to the electric field at that point
3. Equi-potential surface helps to distinguish region of strong field from those of weak field
4. No two equipotential surfaces can interest each other
5. Equi-potential surfaces offer an alternative, visual picture also of field lines around a charge field.

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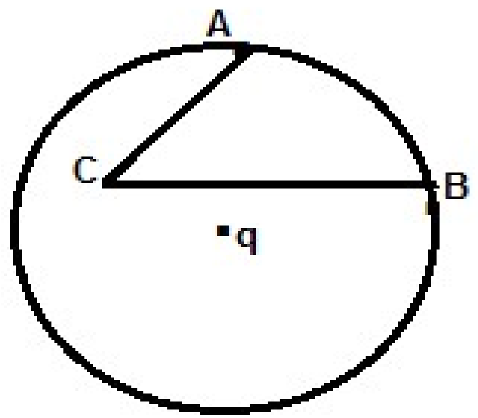
NCERT NUMERICAL

1. What is the work done in moving a test charge 'q' through a distance of 1cm along the equatorial axis of an electric dipole?

2. What would be the work done if a point charge +Q is taken from a point A to B

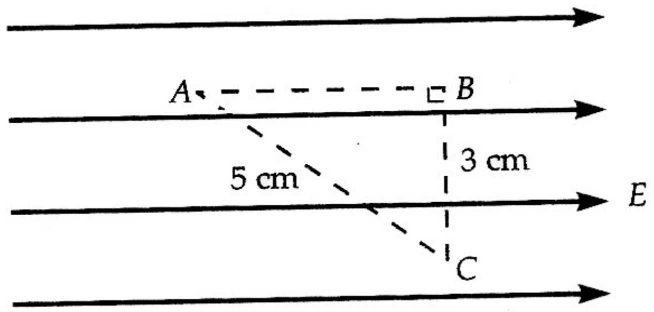
(a) On the circumference of the circle with another point charge $\pm q$ at the center.

(b) Via C.



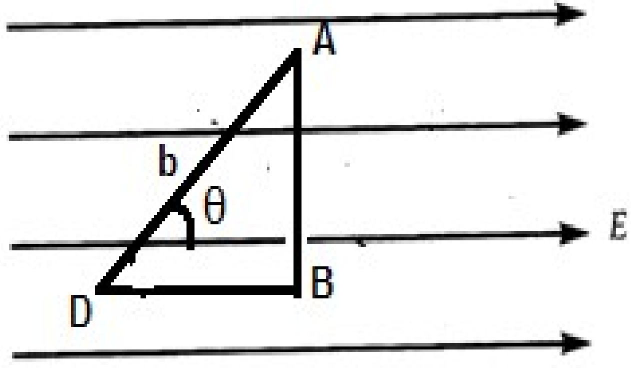
NCERT NUMERICAL

1. Three points A, B, and C lie in a uniform electric field $E = 5 \times 10^{-3} N/c$ as shown in the figure. Find out the potential difference between A and C.



NCERT NUMERICAL

2. A test charge 'q_0' is moved from A to D along the path ABD as shown in the figure. Find the P.D between points D and A.



NOTE

Points to Ponder:

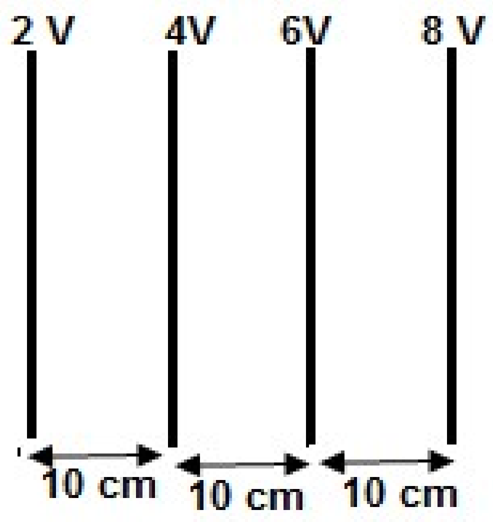
- ✓ In general; $\vec{E} = -\vec{\nabla}V$
- ✓ In Cartesian co-ordinate system; $\vec{E} = \frac{-\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$
- ✓ In 2D polar coordinate system (r,θ); $\vec{E} = \frac{-\partial V}{\partial r}\hat{r} - \frac{1}{r}\frac{\partial V}{\partial \theta}\hat{\theta}$
- ✓ In one dimensional Cartesian coordinate system; $\vec{E} = \frac{-dV}{dx}\hat{i}$
- ✓ In one dimensional polar coordinate system; $\vec{E} = \frac{-dV}{dr}\hat{r}$
- ✓ Now potential at a point; $V = -\int_{\infty}^{r} E dr$

NCERT NUMERICAL

3. Given $V = x^2y + yz$, calculate the magnitude of $\vec{E}$ at (1, 3, 1)

NCERT NUMERICAL

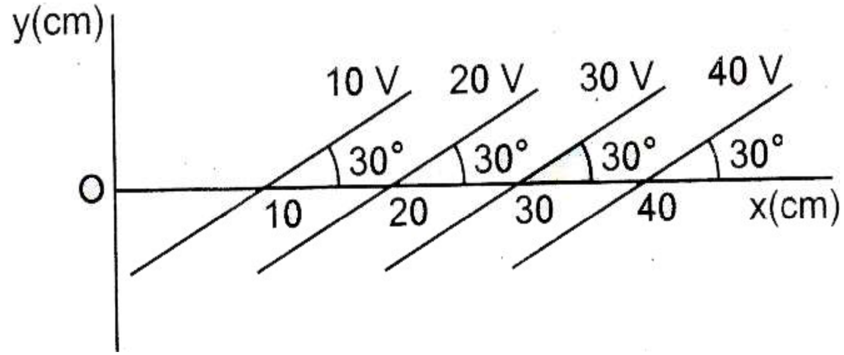
4. Equipotential, surface, with potential 2V, 4V, 6V, and 8V parallel to y-axis as shown. Calculate the electric field intensity



HOME ASSIGNMENT

1. A metal wire is bent in a circle of radius 10 cm It is given a charge of 200 μC which spreads on it uniformly. Calculate the electric potential at its centre.

2. In the above equipotential surface. What can you say about the magnitude and direction of E?



3. Describe schematically the equipotential surfaces corresponding to

(a) a constant electric field in the z-direction,

(b) a field that uniformly increases in magnitude but remains in a constant (say, z) direction,

(c) a single positive charge at the origin, and (d) a uniform grid consisting of long equally spaced parallel charged wires in a plane.

THANKING YOU

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