$\sqrt{h^2+a^2}$

$$E = \frac{\rho_s}{2\varepsilon_0}\left[1 - \frac{h}{\sqrt{h^2+a^2}}\right]\hat{a_z}$$

Electric field due to infinite sheet

$\alpha = 90^\circ$

$$\therefore \boxed{E = \frac{\rho_s}{2\varepsilon_0}\hat{a_z}}$$

Electric flux density:

Electric flux: The lines drawn to trace the direction in which a positive test charge will experience force due to the main charge are called the lines of force.

These lines of force are known as electric flux which is equal to the charge itself. The symbol is '$\psi$' and its unit is Coulombs. The total number of lines of force in any particular E field is called the electric flux. It is represented by the symbol $\psi$. Unit is Coulomb C.

Electric flux density:

It is given by the ratio between number of flux lines crossing a surface normal to the lines and the surface area.

The direction of $\vec{D}$ is the direction of the flux lines at that point.

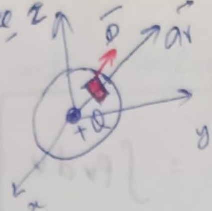
$$D = \frac{\psi}{S} \quad \frac{\text{Total flux}}{\text{Surface area}}$$

Units: Coulombs$/m^2$.

Consider imaginary sphere of radius r ... placed at centre

Flux density at any point on the surface is

$$\vec{D} = \frac{Q}{4\pi r^2} \hat{a_r} \quad C/m^2$$




vector form

$$\vec{D} = \frac{d\psi}{ds} \hat{a_n} \quad C/m^2$$

$S = 4\pi r^2$.

$d\psi \Rightarrow$ Total flux lines crossing normal thro' the diff surface area $ds$

Relation between D and E

$$\vec{E} = \frac{Q}{4\pi\varepsilon r^2} \hat{a_r}$$

$$\vec{E} = \vec{D}/\varepsilon$$

$$\boxed{\vec{D} = \varepsilon\vec{E}}$$

Electric flux density is also called as electric displacement.

Gauss's law

Objective:- To learn one of the fundamental law of electromagnetics

To find fields due to symmetrical charge distributions

Gauss's law constitutes one of the fundamental laws of electromagnetism.

Gauss law states that the total electric flux $\psi$ through any closed surface is equal to the total charge enclosed by that surface.

$$\psi = Q_{enc}$$

$$\psi = \oint_S d\psi$$

$$\psi = \oint_S \vec{D}\cdot ds = \text{total charge enclosed}$$

$$Q = \int_v \rho_v \, dv$$

If potential at infinity is zero, $V_A = 0$ as $r_A \to \infty$

potential at any point $r_A$ due to point charge $Q$ located at origin

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$ => absoute potential

Relationship between $E$ & $V$

The potential difference between points A & B is independent of the path taken.

$$V_{BA} = -V_{AB}$$

$$\oint E \cdot dl = V_{BA} + V_{AB} = 0$$

$$\boxed{\oint \vec{E} \cdot dl = 0} \rightarrow (1)$$

The line integral of E along a closed path must be zero. This implies that no net work is done in moving a charge along a closed path in an electrostatic field.

Apply Stoke's theorem

$$\oint \vec{E} \cdot dl = \int_S (\nabla \times \vec{E}) \cdot ds = 0$$

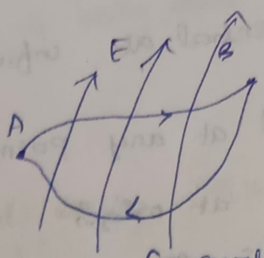
$$\boxed{\nabla \times \vec{E} = 0} \rightarrow (2)$$

If Eqn (1) & (2) are satisfied, then the vector field is said to be conservative, or irrotational.

Vectors whose line integral does not depend on the path of integration are called conservative ~~field~~. vectors.

From the definition

$$V = -\int E \cdot dl$$




Conservative Nature of Electrostatic field

$$dV = -E \cdot dl$$

$$dV = -E_x\,dx - E_y\,dy - E_z\,dz$$

$$dV = \frac{\partial V}{\partial x}dx + \frac{\partial V}{\partial y}dy + \frac{\partial V}{\partial z}dz = -E \cdot dl$$

Comparing two expressions,

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

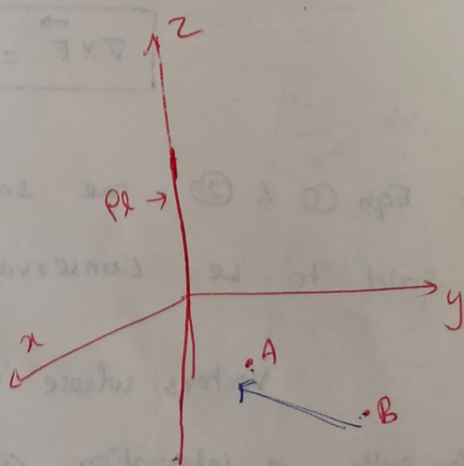
$$\therefore \boxed{E = -\nabla V}$$

Electric field intensity is the gradient of V.
Negative sign shows that the direction of E is opposite to the direction in which V increases. i.e. E is directed from higher to lower levels of V.

Potential due to different charge distributions.

i) Uniformly charged line.

$$V_{ba} = -\int_b^a E \cdot dl$$




$$= -\int_b^a E \cdot dr$$

$$= -\frac{\rho_l}{2\pi\varepsilon_0}\int_b^a \frac{1}{r}\,dr$$

$$= -\frac{\rho_l}{2\pi\varepsilon_0}\left[\ln(r)\right]_b^a$$