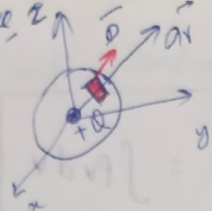
Flux density at any point on the surface is

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



vector form

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

$S = 4\pi r^2$.

Relation between D and E

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

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

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

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

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 ψ through any closed surface is equal to the total charge enclosed by that surface.

$$\psi = Q_{enc}$$

$$\psi = \oint_s d\psi$$

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

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

or

$$\boxed{Q = \oint_S \vec{D}\cdot ds = \int_V \rho_v \, dv}$$ Integral form

Applying divergence theorem

$$\oint \vec{D}\cdot ds = \int_V \nabla\cdot\vec{D} \, dv$$

Comparing two equations

$$\therefore \boxed{\rho_v = \nabla\cdot\vec{D}}$$ Differential or point form.

which is first of the four Maxwell's equations.
Equation states that the volume charge density is the same as the divergence of electric flux density.
It relates the definition of divergence & also
(WKT ρ_v is simply at charge per unit volume)

Advantages :-

Gauss' law provides an easy means of finding E or D for symmetrical charge distributions, such as a point charge, an infinite line charge, an infinite cylindrical surface charge & a spherical distribution of charge.

Proof of Gauss's law :-

Consider a point charge Q kept at the origin.
Consider a small area 'ds' on the surface of the sphere
Let $d\psi$ be the flux crossing the surface.

$$d\psi = \vec{D}\cdot\vec{ds}$$

$$= D \, ds \cos 0^\circ$$

$$d\psi = D \, ds$$

$$\vec{E} = \frac{\vec{D}}{\varepsilon_0}$$

$$\vec{E} = \frac{\rho_s}{2\varepsilon_0}\hat{a}_z$$

Gauss Divergence theorem

From gauss law

$$\iint D\cdot ds = Q$$

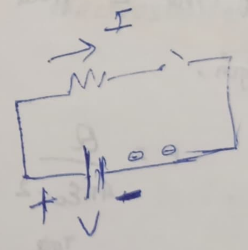
$$Q = \iiint \rho_v \, dv$$

$$\iint D\cdot ds = \iiint \rho_v \, dv$$

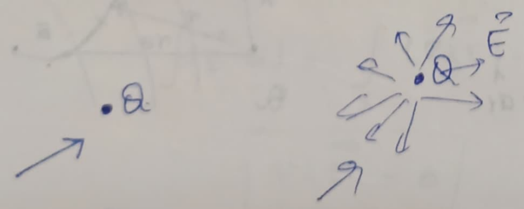
$$\boxed{\iint D\cdot ds = \iiint \nabla\cdot D \, dv}$$

from point form of gauss law,

$$\nabla\cdot D = \rho_v$$



Electric Potential:



We wish to move a point charge Q from Point A to Point B in an electric field E. From coulomb's law, force on Q is $F = QE$, so that the work done by external force in displacing the charge by dl

$$dW = -F\cdot dl$$

$$= -QE\cdot dl$$