$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q q_0}{r_{12}^2}\hat{r}_{12}$$

$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q q_0}{(r_{12})^3}\vec{r}_{12} \quad \left\{ \because \hat{r} = \frac{\vec{r}}{|\vec{r}|} \right.$$

Now:- $\vec{E} = \frac{\vec{F}}{q_0} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r_{12})^3}\vec{r}_{12}$

→ **Principle of Super-Position :-**

It states that electric Intensity at Point due to several charges is vector sum of electric intensities by each charge individually in the absence of other charges.

$\vec{E}_1, \vec{E}_2 \ldots \vec{E}_n$ are Electric field Intensities due to individual charges & $\vec{E}$ is resultant intensity, then acc to superposition Principle.

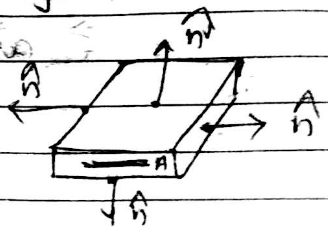
$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \ldots \vec{E}_n$$

Find E.F.I due to Long straight uniformly charge wire having density λ:-

Let us consider a line charge of charge density along x-axis, we have to cal. E.F.I at point P which is placed asymmetrically on same x-y plan

→ Find E.F.I. at a point due to an infinite sheet of charge having charge density σ

Let us consider an infinite sheet of charge having charge density σ, & a rectangular Gaussian surface around an elementary Area A of that infinite sheet of charge which encloses charge Q



$$Q = \sigma A \quad \text{(Charge Density)}$$

Now applying Gauss Law, the total Φ flux will be

$$\oint_S D . ds \, \hat{n} = Q$$

$$\oint D . ds \, \hat{n} = \sigma A$$

Now by splitting the surface Integral it becomes

$$\underset{Top}{\oint} D . ds \, \hat{n} + \underset{Bottom}{\oint} D . ds \, \hat{n} + \underset{Left}{\oint} D . ds \, \hat{n} + \underset{Right}{\oint} D . ds \, \hat{n} = \sigma A$$

The surface Integral for left & right are zero as Electric flux & $\hat{n}$ are mutually $\perp$ to each other. Hence there Dot product is 0 charge on boundary & it is said to be continous across the boundary.

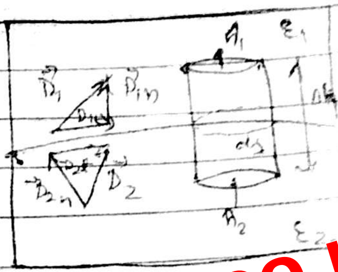
As $D = \varepsilon E$

$$E_{1t} = E_{2t}$$

$$\frac{\vec{D}_{1t}}{\varepsilon_1} = \frac{\vec{D}_{2t}}{\varepsilon_2} \Rightarrow \boxed{\frac{\vec{D}_{1t}}{\vec{D}_{2t}} = \frac{\varepsilon_1}{\varepsilon_2}}$$

Thus tangential component of E. flux Density is discontinous at the boundary.

Now let us consider a small coin shaped volume that intersects the interface & encloses an area 'ds' of the interface. The Height of coin Δh is negligible in comparison to diameter of Base.



Now by apply Gauss's Law :-

$$\oint_S \vec{D}.ds\hat{n} = Q$$

Since the Height of Box is small in comparison to the area ds so then the volume shrinks the two outer surfaces ds_1 & ds_2 approach each other, then $\vec{D}$-lines will pass only through the Top & bottom surfaces.

$$\oint_S \vec{D}.ds = \sigma S$$

$$\Rightarrow (D_{1n}\, ds_1 - D_2\, ds_2) = \sigma S \quad . \; D_{1n} S_1 - D_{2n} S$$

As $S_1 = S_2$

$$\Rightarrow (D_{1n} - D_{2n}) = \sigma$$

where σ is interface charge density. If no free charge exist at interface,