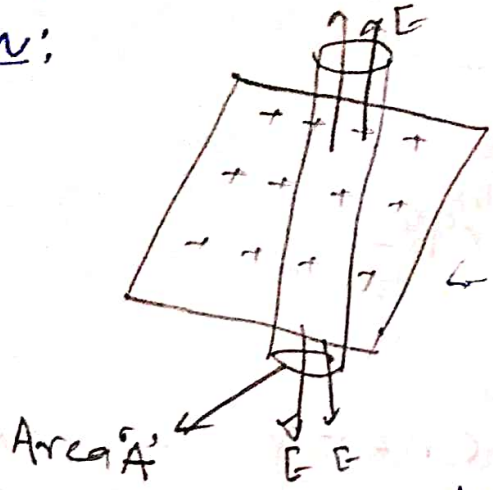
'Planar Symmetry' ~~Gaussian Surface~~

Charge distribution with planar symmetry include infinite sheets.

Eg. Using Gauss' Law, find the electric field of a very large uniform sheet of charge with σ coulombs per sq. meter.

Solution:



We take a Gaussian surface in the shape of a cylinder of base area A that extends symmetrically on either side of the sheet of charge, as shown in figure.

Here, the electric field is parallel to the curved surface of the cylinder which therefore intercept no flux.

On each of the two circular ends, the electric field is perpendicular to the surface, & so it will contribute to the electric flux.

Total flux is

$$\phi_E = \oint \vec{E} \cdot d\vec{A} = \underbrace{\int \vec{E} \cdot d\vec{A}}_{\text{bottom circular surface}} + \underbrace{\int \vec{E} \cdot d\vec{A}}_{\text{top circular surface}} + \underbrace{\int \vec{E} \cdot dA}_{\text{curved surface}}$$

area of circular portion is A

$$\therefore \phi_E = EA + EA = \frac{Q_{inside}}{\epsilon_0}$$

The amount of charge inside the Gaussian surface is the charge per unit area multiplied by the area of the sheet enclosed by the surface, or $Q_{inside} = \sigma A$.

So, Gauss' Law

$$2EA = \frac{\sigma A}{\epsilon_0}$$

$$\Rightarrow \boxed{E = \frac{\sigma}{2\epsilon_0}}$$