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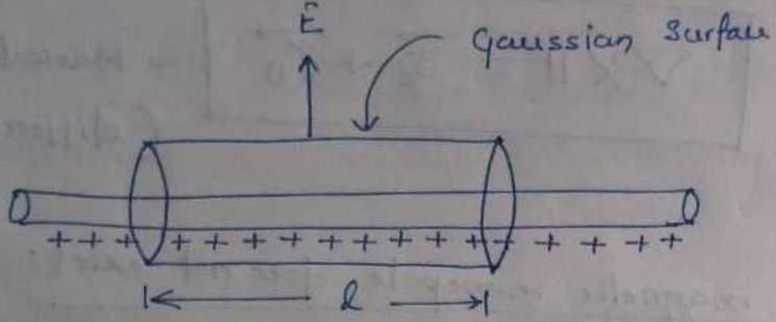
⇒ Application of Gauss's Law:

Gauss's law theorem can be used to calculate the electric intensity due to —

(1). an infinitely long straight charged



Let us considered infinitely long wire with linear charge density 'λ' and length L. To calculate electric field, assume a cylindrical gaussian surface. electric field $\vec{E}$ is radial in direction, the flux through the end of the cylindrical surface will be Zero.

Surface area of the curve cylindrical Surface is $2\pi r l$.
The electric flux through the curve is —

$$E \times 2\pi r l$$

According to Gauss's law

$$\Rightarrow \phi = \frac{q}{\epsilon_0}$$

$$\Rightarrow E \times 2\pi r l = \frac{\lambda l}{\epsilon_0}$$

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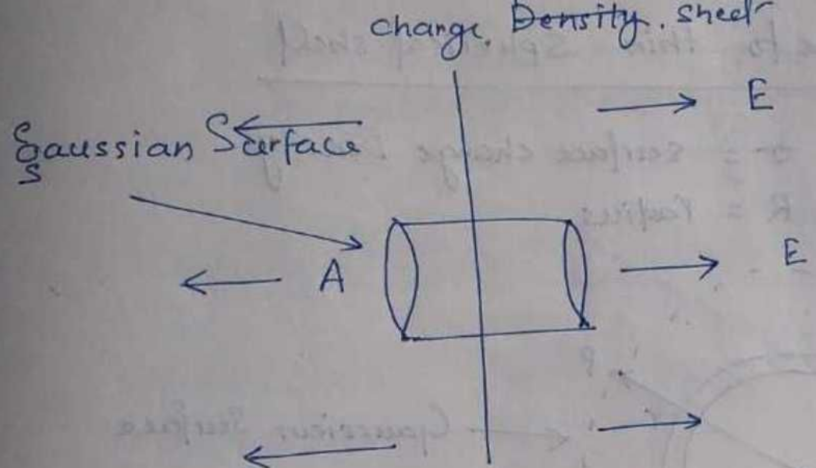
$$\boxed{E = \frac{\lambda}{2\pi \epsilon_0 r}}$$

Note: If direction of the electric field is radially outward then linear charge density is positive.

⇒ On the other hand, it will be radially inward if the linear charge Density is negative.

⇒ ② Electric field due to infinite plate sheet

σ = surface charge Density.
A = crossectional Area.



⇒ The Direction of Electric field due to an infinite charge sheet is perpendicular to the plane of the sheet.

⇒ Let consider a cylindrical Gaussian surface, whose axis is normal to the plane sheet.

From Gauss law

$$\Phi = \frac{q}{\epsilon_0}$$

The curve surface area and an electric field are normal to each other, thereby producing zero electric flux.

So, net electric flux is

$$\Phi = EA - (-EA)$$

$$\Phi = 2EA$$

then we can write

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

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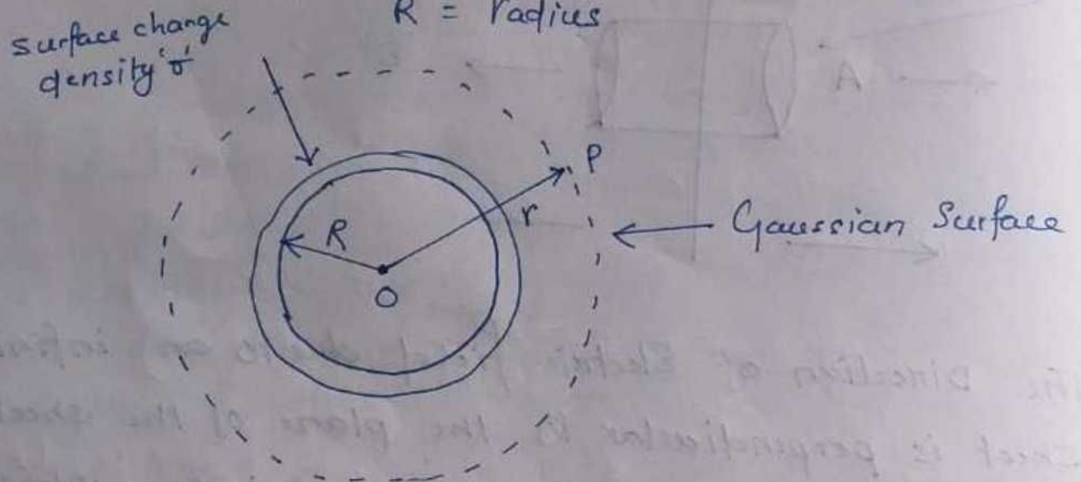
The term A cancels out which means electric field due to an infinite plane sheet is independent of cross-sectional Area A and equals to:

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

(3) Electric field due to thin spherical shell

Let consider, σ = surface charge Density
R = radius



Electric field outside the spherical shell

Take point 'p' to find out the electric field outside the spherical shell,
r = distance from the centre of the spherical ~~cot~~ shell.

According to Gauss's law

$$\phi = \frac{q}{\epsilon_0}$$

The ~~charge~~ enclosed charge inside Gaussian surface 'q' will be $\sigma \times 4\pi R^2$.

Total electric flux the Gaussian surface will be.

$$\phi = E \times 4\pi r^2$$

∴ From Gauss's law, we can write

$$E \times 4\pi r^2 = \sigma \times \frac{4\pi R^2}{\epsilon_0}$$

$$E = \frac{\sigma R^2}{\epsilon_0 r^2}$$

∴ Putting the Value of charge Density σ as $q/4\pi R^2$, we can write

$$\boxed{E = \frac{kq}{r^2}}$$

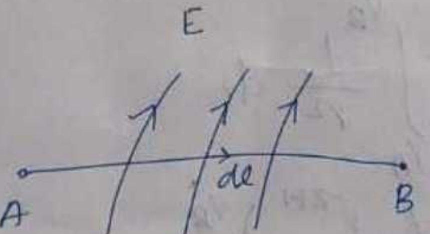
in Vector form

$$\boxed{\vec{E} = \frac{kq}{r^2}\hat{r}}$$ where r is the radius Vector.

⇒ Electrostatic potential

– Electrostatic potential is related to the work done in carrying a charge from one point to the other in the presence of an electric field.

Let us



Q = charge
E = electric field intensity

$$F = QE$$

$$dW = -F \cdot dl$$

~~For all A to B~~ $$W = -\int_A^B F \cdot dl$$

For all A to B
$$W = -\int Q \cdot E \cdot dl \Rightarrow W = -Q\int_A^B E \cdot dl$$

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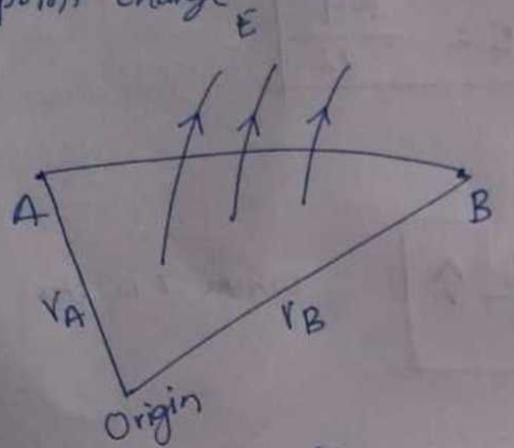
Dividing both side by Q.

$$\frac{W}{Q} = -\int_A^B E \cdot dl$$

$$\Rightarrow V = \frac{W}{Q} = -\int_A^B E \cdot dl.$$

For origin point charge



$$E = \frac{Q}{4\pi\epsilon_0 r^2} a_r$$

$$\therefore V_{AB} = -\int_A^B \frac{Q}{4\pi\epsilon_0 r^2} a_r \cdot dr a_r$$

$$V_{AB} = -\int_A^B \frac{Q}{4\pi\epsilon r^2} dr$$

$$V_{AB} = -\frac{Q}{4\pi\epsilon_0} \int_{r_A}^{r_B} \frac{1}{r^2} dr$$

$$V_{AB} = -\frac{Q}{4\pi\epsilon} \left(\frac{r^{-2+1}}{-2+1}\right)_{r_A}^{r_B}$$

$$V_{AB} = \left(\frac{Q}{4\pi\epsilon_0 r}\right)_{r_A}^{r_B}$$

$$V_{AB} = \frac{Q}{4\pi\epsilon r_B} - \frac{Q}{4\pi\epsilon r_A}$$

$V_{AB} = V_B - V_A$

↳ reference.

↳ Potential ~~differ~~ at B w.r.t reference A

$r_A \longrightarrow \infty$, $V_A \rightarrow 0$

$\therefore V_{AB} = V_B$

$\therefore \boxed{V_{AB} = \frac{Q}{4\pi\epsilon_0 r}}$