

FORMULA SHEET

Chapter - 1

1. Charge on a body

$$Q = \pm ne$$

$n \rightarrow$ no. of electrons, $e \rightarrow$ charge on electron
 $e = 1.6 \times 10^{-19} \text{ C}$

2. Coulomb's law

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$



$$F = k \frac{q_1 q_2}{r^2}$$

q_1 and $q_2 \rightarrow$ point charges

$\epsilon_0 =$ permittivity of free space

$$= 8.85 \times 10^{-12} \text{ N}^{-1} \text{ m}^{-2} \text{ C}^2$$

$k =$ Coulomb's constant

$$= 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

3. Vector form of Coulomb's law

$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r_{12}^2} \cdot \hat{r}_{12}$$

$$\vec{F}_{21} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r_{21}^2} \hat{r}_{21}$$

$$\vec{F}_{12} = -\vec{F}_{21}$$

4. Relative Permittivity (ϵ_r)

$$\epsilon_r = \frac{\epsilon}{\epsilon_0} = \frac{F_0}{F} = K$$

$F_0 \rightarrow$ Force in free space/vac

$F \rightarrow$ Force in any medium

$\epsilon \rightarrow$ Permittivity of medium

$K \rightarrow$ Dielectric constant

5. Principle of Superposition

For a system of n charges, force on any charge (say on charge '1')

$$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + \dots + \vec{F}_{1n}$$

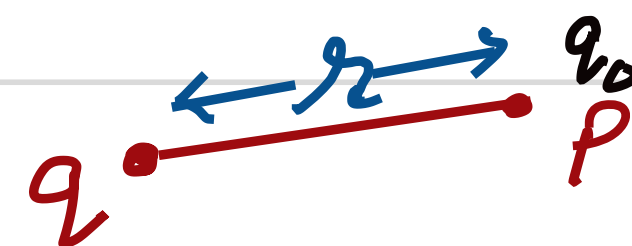
$\vec{F}_1$ not force on charge 1

$\vec{F}_{12} \rightarrow$ force on charge 1 due to charge 2

$\vec{F}_{13} \rightarrow$ " " " " charge 3

6. Electric field due to a point charge

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2}$$



and

$$F = q_0 E$$

$q_0 \rightarrow$ Test charge

or

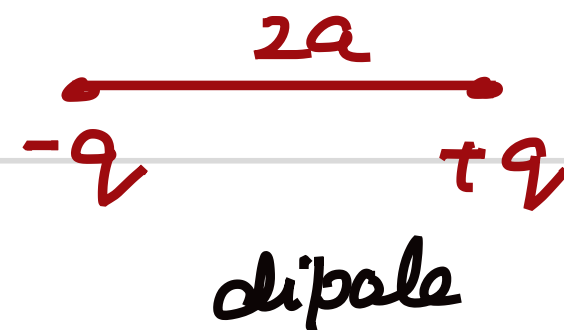
$$\vec{E} = \frac{\vec{F}}{q_0}$$

$\rightarrow$ By coulomb's law

7. Electric dipole moment (p)

$$p = 2aq$$

$2a \rightarrow$ length of dipole



8. Electric field due to an electric dipole

(i) On its axial line

$$E_{axial} = \frac{1}{4\pi\epsilon_0} \frac{2pr}{(r^2 - a^2)^2}$$

For short dipole

$$E_{axial} = \frac{1}{4\pi\epsilon_0} \frac{2p}{r^3}$$

$p \rightarrow$ Electric dipole moment

(ii) On Equatorial plane

$$E_{eq} = \frac{1}{4\pi\epsilon_0} \frac{p}{(r^2 + a^2)^{3/2}}$$

For short dipole

$$E_{eq} = \frac{1}{4\pi\epsilon_0} \frac{p}{r^3}$$

$$\vec{E}_{ax} = -2\vec{E}_{eq}$$

9. Torque on dipole (In uniform electric field)

$$\tau = pE \sin\theta$$

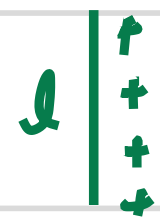
$$\vec{\tau} = \vec{p} \times \vec{E}$$

10. Charge distribution

(i) linear charge density

$$\lambda = \frac{Q}{l}$$

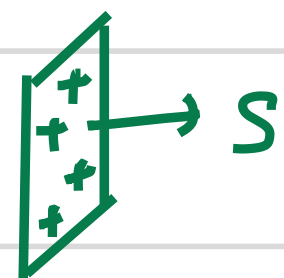
$l \rightarrow$ length of charge



(ii) Surface charge density

$$\sigma = \frac{Q}{S}$$

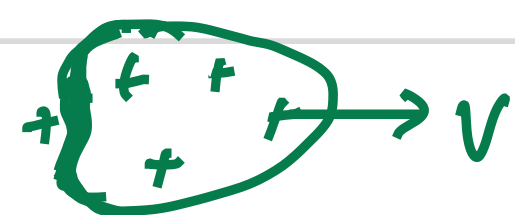
$S \rightarrow$ surface area



(iii) Volume charge density

$$\rho = \frac{Q}{V}$$

$V \rightarrow$ volume



11. Gauss' Law

Flux

$$\phi = \oint \vec{E} \cdot d\vec{s} = \frac{q_{en}}{\epsilon_0}$$

$\rightarrow$ charge enclosed

12. Gauss' law applications

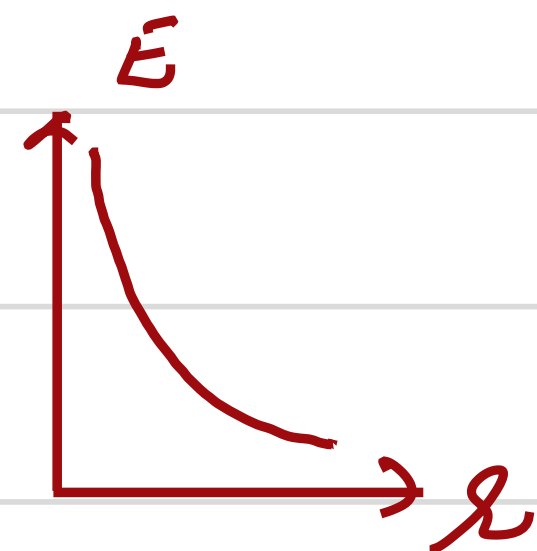
(i) Electric field due to a uniformly charged wire

wire

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

$\propto$

$$\vec{E} = \frac{\lambda}{2\pi\epsilon_0 r} \hat{n}$$



(ii) for a uniformly charged sheet

$$\vec{E} = \frac{\sigma}{2\epsilon_0}, \quad \vec{E} = \frac{\sigma}{2\epsilon_0} \hat{n}$$

$\sigma \rightarrow$ surface charge density

(iii) For a uniformly charged spherical thin shell

- Outside the shell ($r > R$) $R \rightarrow$ Radius of shell

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} = \frac{\sigma R^2}{\epsilon_0 r^2}$$

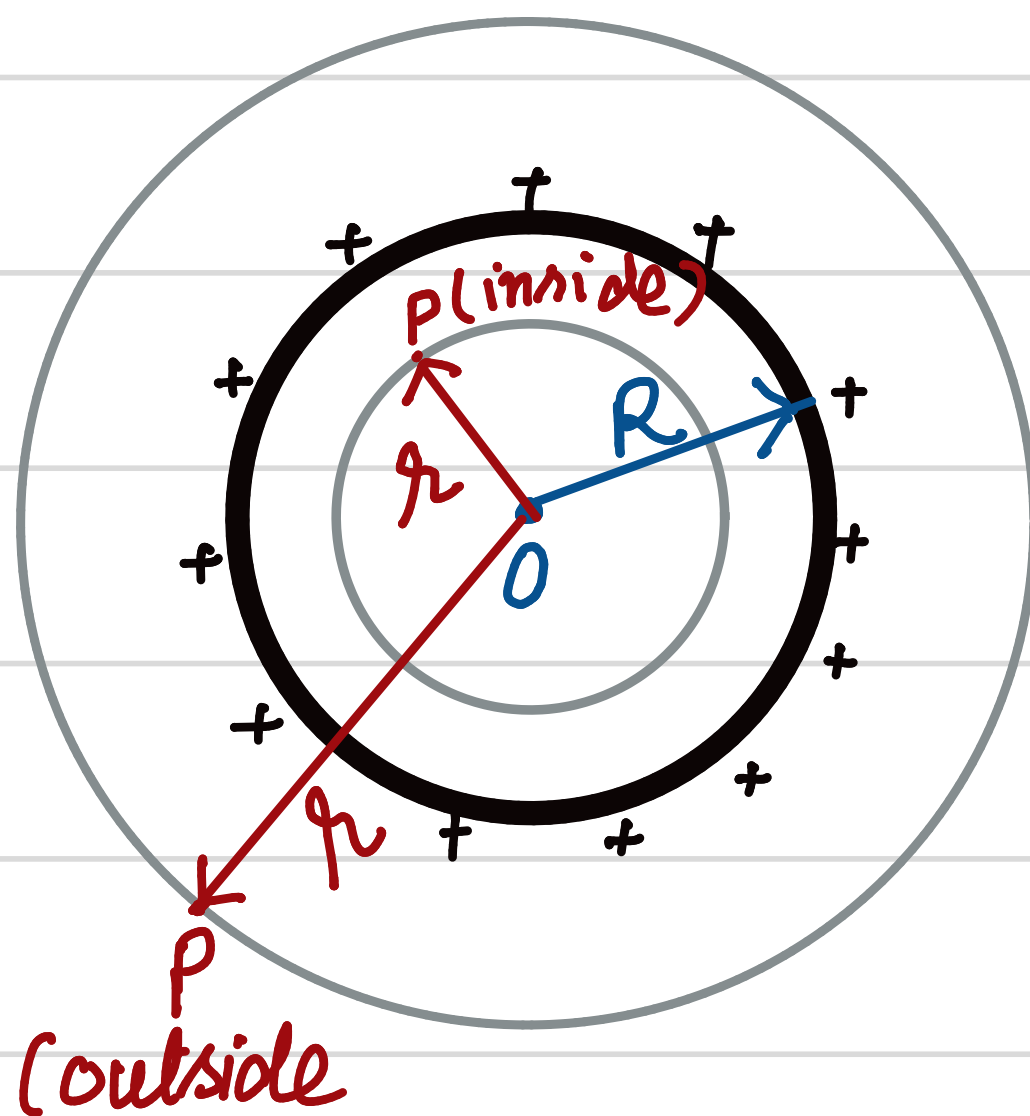
- Inside the shell

$$E = 0$$

$$[\because q = 0]$$

- At the surface of shell

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{R^2} = \frac{\sigma}{\epsilon_0}$$



$R \rightarrow$ Radius of the shell