FORMULA SHEET — Chapter-1

1. Charge on a body

$$q = \pm ne$$

$n \rightarrow$ no. of electrons, $e \rightarrow$ charge on electron

$e = 1.6 \times 10^{-19}\,C$

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

ϵ_0 = permittivity of free space

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

k = coulomb's constant

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

3. Vector form of coulomb law

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

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

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

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')

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

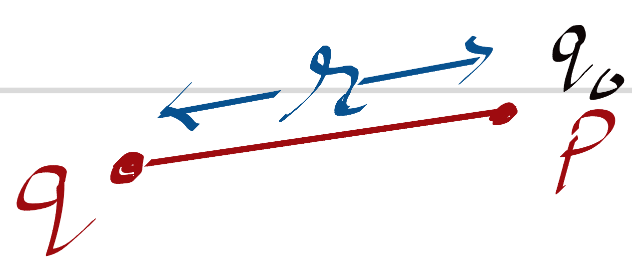
$\vec{F}_1$: net force on charge 1

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

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

6. Electric field due to a point charge

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



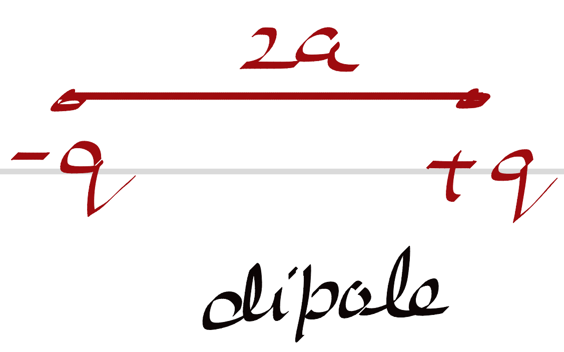
and $F = q_0 E$ — $q_0 \rightarrow$ Test charge

or $\vec{E} = \frac{\vec{F}}{q_0}$ $\longrightarrow$ 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)

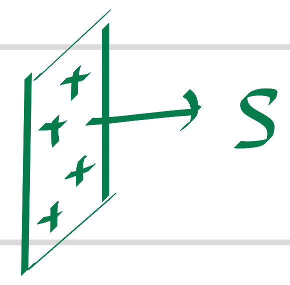
$$\tau = pE\sin\theta$$
$$\vec{\tau} = \vec{p} \times \vec{E}$$

10. Charge distribution

(i) linear charge density $\boxed{\lambda = \frac{q}{l}}$ → length of charge

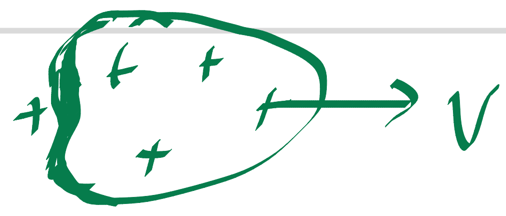
(ii) Surface charge density

$$\boxed{\sigma = \frac{q}{S}}$$ → surface area



(iii) Volume charge density

$$\boxed{\rho = \frac{q}{V}}$$ → volume



11. Gauss' law

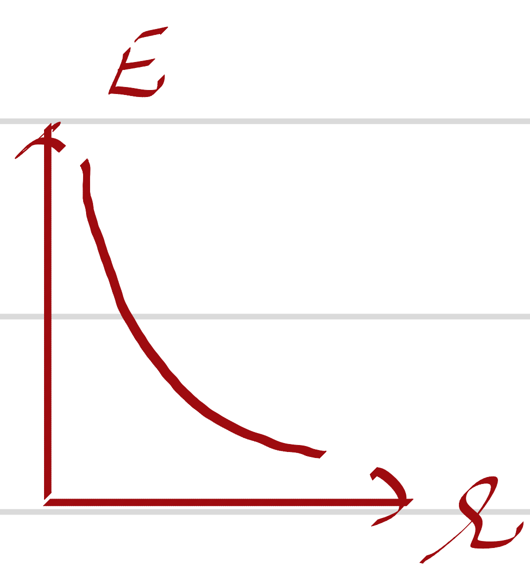
Flux $$\boxed{\phi = \oint \vec{E} \cdot \vec{ds} = \frac{q_{en}}{\epsilon_0}}$$ → charge enclosed

12. <u>Gauss' law applications</u>

(i) Electric field due to a uniformly charged wire

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

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



(ii) For a uniformly charged sheet

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

σ → surface charge density

(III) For a uniformly charged spherical thin shell

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

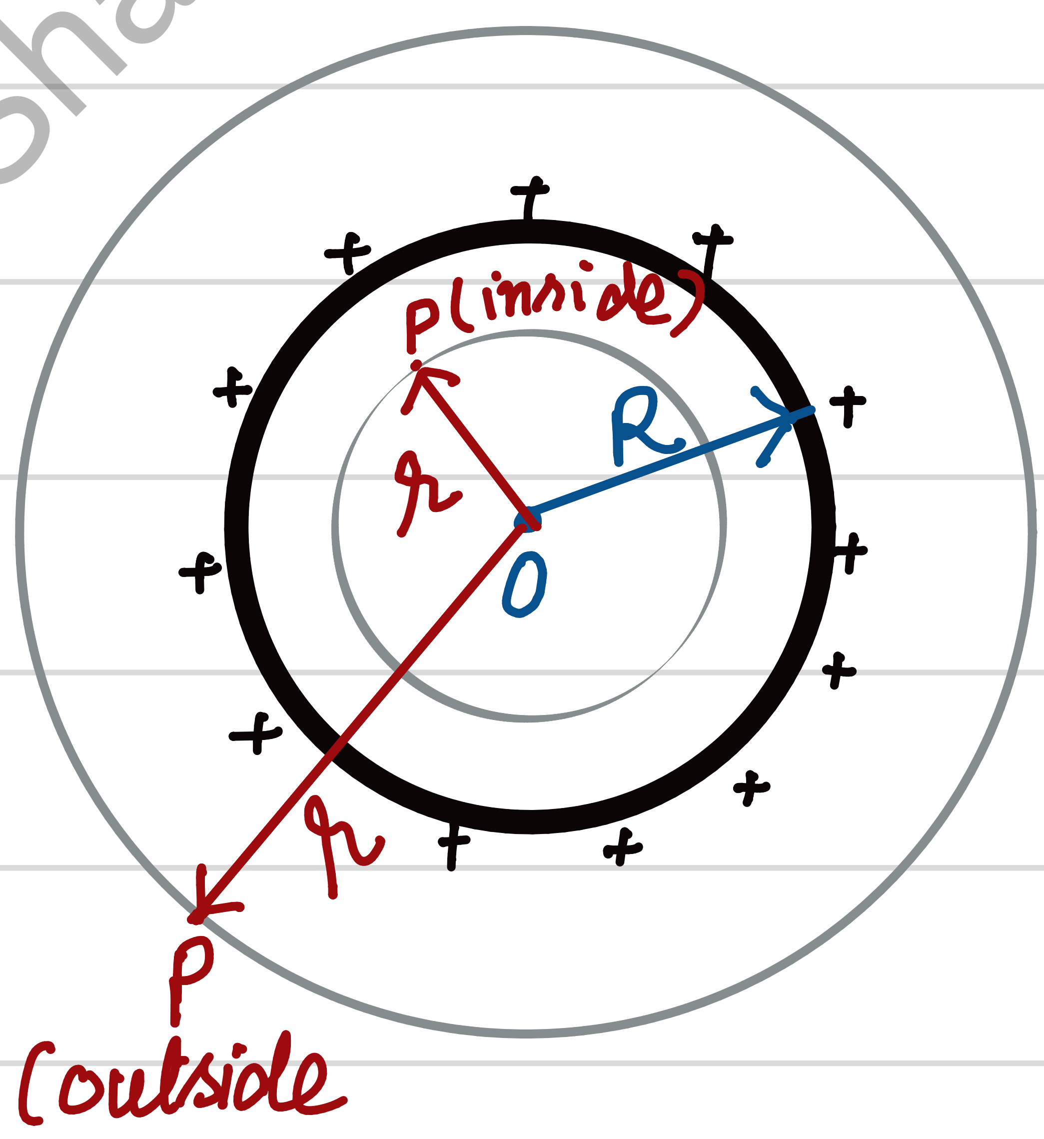
$$E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2} = \frac{\sigma R^2}{\epsilon_0 r^2}$$

- 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 → Radius of the shell