MIND MAP

Electrostatics

1. Electric charge properties:

- Similar charges repel each other and Opposite charges attract each other
- Charge adds like real numbers
- Charges of isolated system remains conserved
- Charge is quantised
- Charge is invariant from frame of reference

2. Coulomb's Law

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

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N - m^2}$$

3. Coulomb's Law in Vector form

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

4. Electric Field due to point charge

$$E = \frac{kQ}{r^2}$$

- For positive charge field is radially outwards.
- For negative charge field is radially inwards.

5. EFI due to system of point charges

$$\vec{E}_{net} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3$$

6. EFI on perpendicular bisector of line joining two point charges

$$E_{net} = \frac{k\, 2q\, x}{(x^2 + R^2)^{\frac{3}{2}}}$$

7. EFI on the axis of uniformly charged ring

$$E = \frac{k\, Q\, x}{(x^2 + R^2)^{\frac{3}{2}}}$$

8. EFI due to uniformly charged thin straight wire

$$E_{\perp} = \frac{k\lambda}{r}(\sin\theta_1 + \sin\theta_2) \qquad E_{||} = \frac{k\lambda}{r}(\cos\theta_1 - \cos\theta_2)$$

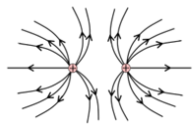
9. EFI due to uniformly charged arc at centre of curvature

$$E = \frac{2k\lambda}{R} \sin\left(\frac{\alpha}{2}\right)$$

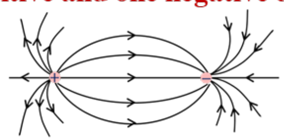
10. EFI on axis of uniformly charged disc

$$E = \frac{\sigma}{2\epsilon_0}[1 - \cos\theta]$$

11. Electric field lines due to two positive charges



11. Electric field lines due to One positive and one negative charge



12. Gauss Law

$$\oint \vec{E}.\overrightarrow{dA} = \frac{\sum q_{inside}}{\epsilon_0}$$

$$\oint = \frac{\sum q_{inside}}{\epsilon_0}$$

13. Motion of charged particle in electric field

$$\vec{F} = q\,\vec{E}$$

14. Electric Flux

$$\phi = \vec{E} \cdot \vec{A} \qquad \Phi = E\, A \cos\theta$$

15. Net flux linked with closed Surface is-

$$\Phi = \oint \vec{E} \cdot d\vec{A}$$

16. EFI due to thin spherical shell

$r < R$: $E = 0$

$r = R$: $E = \frac{kQ}{R^2}$

$r > R$: $E = \frac{kQ}{r^2}$

17. EFI due to uniformly charged solid sphere

$r < R$: $E = \frac{\rho\, r}{3\, \epsilon_0}$

$r = R$: $E = \frac{\rho R}{3\epsilon_o}$

$r > R$: $E = \frac{kQ}{r^2}$

18. EFI due to infinite line charge

$$E = \frac{2k\lambda}{r}$$

19. EFI due to ∞ long uniformly charged cylindrical shell

$r < R$: $E = 0$

$r > R$: $E = \frac{\sigma R}{r\epsilon_o}$

20. EFI due to ∞ long uniformly charged solid cylinder

$r \le R$: $E = \frac{\rho\, r}{2\epsilon_o}$

$r > R$: $E = \frac{\rho R^2}{2r\epsilon_o}$

21. EFI due to ∞ long uniformly charged sheet

$$E = \frac{\sigma}{2\epsilon_o}$$

MIND MAP

Electric Potential

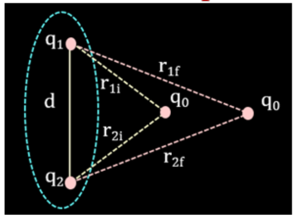
1. **Potential energy of a system of two point charges** $U = \frac{kq_1q_2}{r}$

2. **Work done by electrostatic force**
$W = -\Delta U \quad W = \frac{kq_1q_2}{r_i} - \frac{kq_1q_2}{r_f}$

Work done by electrostatic force in a closed loop = 0

3. **Work energy theorem** $W_{net} = KE_f - KE_i$

4. **Interaction potential energy and self potential energy**



$U_f = \underbrace{\frac{kq_1q_2}{d}}_{\text{Self PE}} + \underbrace{\frac{kq_1q_0}{r_{1f}} + \frac{kq_2q_0}{r_{2f}}}_{\text{Interaction PE}}$

5. **Electric potential from EFI** $V_f - V_i = -\int_{r_i}^{r_f} \vec{E}.d\vec{r}$

6. **EFI from EP** $E_r = -\frac{dV}{dr}$

7. **Electric potential due to**

a. **Uniformly charged thin spherical shell**

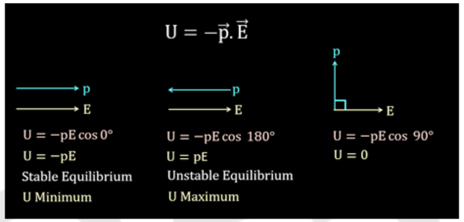
$r < R$, $V_O = \frac{kQ}{R}$, $\quad r > R$, $V_O = \frac{kQ}{r}$,

b. **Uniformly charged solid sphere**

$r < R,\ V_r = \frac{\rho}{6\epsilon_o}(3R^2 - r^2)$

$r = R,\ = \frac{\rho R^2}{3\epsilon_o}$ | $r > R,\ V_r = \frac{kQ}{r}$,

14 **Electric potential energy of electric diapole of Electric field.**



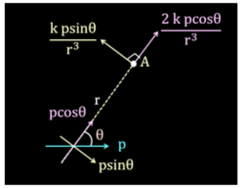
$V_A = \frac{U_{int}}{q_0}$

Due to point charge	$V_A = \frac{kQ}{r}$
Due to system of charges	$V_A = \frac{kQ_1}{r_1} + \frac{kQ_2}{r_2} + \frac{kQ_3}{r_3}$
At the center of uniformly charged ring	$V_O = \frac{kQ}{R}$
At the center of thin charged spherical shell	$V_O = \frac{kQ}{R}$
On the axis of uniformly charged ring	$V_A = \frac{k\,Q}{\sqrt{x^2 + R^2}}$

8. **Equipotential Surface- same potential at each and every point**
- Electric field is perpendicular to the Equipotential surface.
- Net work done by electrostatic force on moving a charged particle in a path having starting and end point on same ES is always zero.

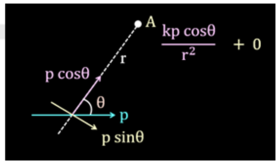
9. **Electric Dipole moment** $p = |\vec{p}| = q\,d$

10. **EFI at general point**



$|E_A| = \frac{kp}{r^3}\sqrt{3\cos^2\theta + 1}$

11. **Electric potential at general point**



$V_A = \frac{k\,\vec{p}.\hat{r}}{r^2}$

$V_A = \frac{k\,\vec{p}.\vec{r}}{r^3}$

12. **Torque of uniform $\vec{E}$ tries to align $\vec{p}$ in direction of $\vec{E}$ through smaller angle.**

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

13. **Torque of uniform $\vec{E}$ tries to align $\vec{p}$ in direction of $\vec{E}$ through smaller angle.**

$\vec{p}_{eq.} = \sum q_i \vec{r}_i$

MIND MAP

Electric Conductors

1. **Induced charges in case of concentric spherical cylinder**

$$\frac{Q_{inc}}{\varepsilon_0}$$

2. **Electric potential due to spherical conductor**

$$V_{in} = \frac{kQ}{R} = V_{surface}$$

$$V_{outside} = \frac{kQ}{r}$$

3. **EFI on the surface of the conductor**

$$\frac{\sigma}{\varepsilon_0}$$

4. **Conductors with cavities**

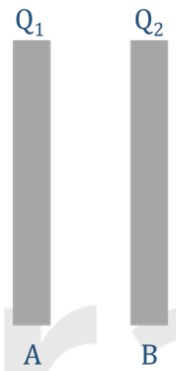
No charge inside cavity

1) EFI inside the cavity is zero.
2) There will be no induced charges on surface of cavity.
3) Potential inside the cavity is same as potential of the conductor.

5. **Faraday Cage**

Electrostatic shielding, faraday cage is an enclosure to block electromagnetic fields

6. **Parallel conducting plate**



On facing surfaces, equal and opposite charges appear.

On outer most surfaces, $\frac{\sum Q_i}{2}$ charge appear.

7. **Electrostatic pressure** $P = \frac{\sigma^2}{2\,\epsilon_0}$

8. **Energy Density**

$$= \frac{1}{2}\epsilon_0 E^2$$

Electric Field Intensity

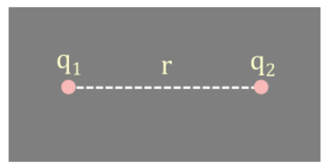
If a conductor is connected with earth through a conducting wire (earthing), potential of the conductor becomes zero

Electric Conductors

Having unlimited supply of free charge is called Conductor

- Electric Field is 0 inside a conductor in electrostatic steady state.
- Charge density inside a conductor is zero.
- Conductor is an equipotential body.

9. **Effect of medium on net electrostatic force**



$$F_{net} = \frac{1}{4\pi \in} \times \frac{q_1 q_2}{r^2}$$

Permittivity of Medium

$$\frac{F_0}{F_{net}} = \frac{\in}{\epsilon_0} = \epsilon_r$$