ELECTROSTATS

FORMULAS ONLY

~~#2 ELECTROSTA~~ (LOL)

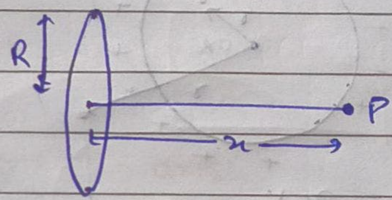
ELECTRIC FIELD

→ General formula

$$\boxed{E = \frac{kQ}{r^2}} \qquad \boxed{E = \frac{kQ\vec{r}}{r^3}}$$

→ Uniformly Charged Ring

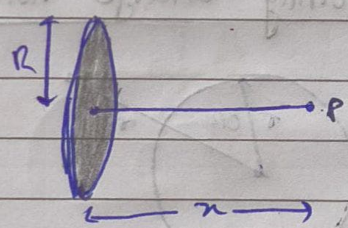
$$\boxed{E_{axis} = \frac{kQx}{(R^2+x^2)^{3/2}}}$$



→ E is max when $x = \pm R/\sqrt{2}$

→ Uniformly charged disc

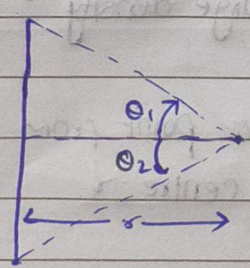
$$E_{axis} = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{x}{\sqrt{R^2+x^2}}\right)$$



→ $\varepsilon_0 = 8.854 \times 10^{-12}$ Farad/m
or $C^2N^{-1}m^{-2}$

→ Uniformly straight wire

$$E_x = \frac{k\lambda}{r}(\sin\theta_1 + \sin\theta_2)$$

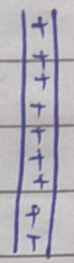


$$E_y = \frac{k\lambda}{r}(\cos\theta_2 - \cos\theta_1)$$

→ Infinite wire ⟹ $E_x = \frac{2k\lambda}{r}$, $E_y = 0$.

→ Uniformly charged large thin plate /sheet:

Non conducting

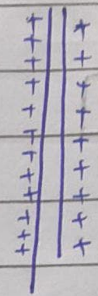


$\vec{E} = \dfrac{Q}{2A\varepsilon_0}$

$= \sigma / 2\varepsilon_0$

$\boxed{\sigma = Q/A}$

Conducting

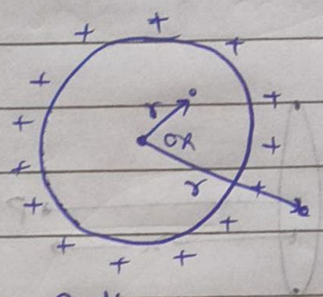


$\vec{E} = Q/2A\varepsilon_0$

$= \sigma/\varepsilon_0$

$\sigma = Q/2 \,/\, A$

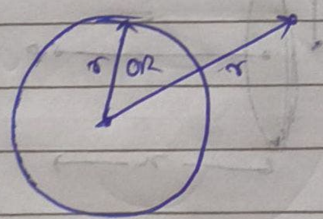
→ Uniformly charged thin spherical shell.



radius = a

$$E \begin{cases} 0 & ; r < a \\ \dfrac{kQ}{r^2} & ; r > a \end{cases}$$

→ Uniformly charge non conducting solid sphere

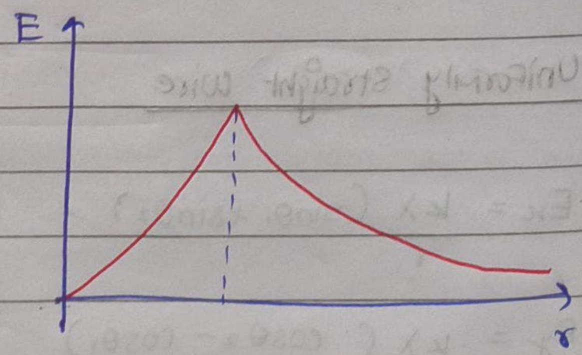


radius a

$$E = \begin{cases} \dfrac{kQr}{a^3} & ; r \leq a \\ \dfrac{kQ}{r^2} & ; r \geq a \end{cases}$$

Vol. charge density = ρ

distance of point from centre = r.



Electric Potential (V)

→ **Point charge**

$$\boxed{V_p = \frac{kQ}{r}}$$ (put Q with sign)

→ 2 Main Methods of finding EP:

① $V = \int dV$ ⟷ ② $\int dV = -\int \vec{E} \cdot d\vec{r}$

choose whatever is easier.

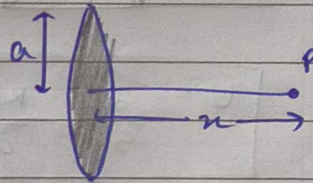
→ **Ring (uniformly charge)**

$$\boxed{V = \frac{kQ}{a}} \rightarrow \text{centre} \qquad \boxed{V_{axis} = \frac{kQ}{\sqrt{a^2+x^2}}} \rightarrow \text{axis}$$

→ valid for both uniform and non uniform charge distribute.

→ **Uniformly charged disc**

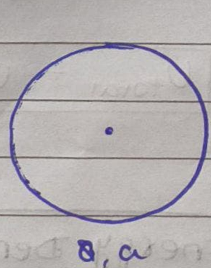
$$V = \frac{\sigma}{2\varepsilon_0}\left[\sqrt{a^2+x^2} - x\right] \rightarrow \text{on axis}$$



→ **Uniformly charged thin spherical shell:**

$$V = \frac{kQ}{r} \rightarrow r \geq a \quad \text{(outside)}$$

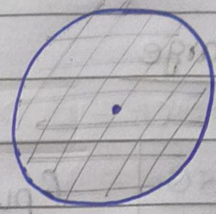
$$V = \frac{kQ}{a} \rightarrow r \leq a \quad \text{(inside)}$$



→ Uniformly charge non-Conducting solid sphere –

$V = \frac{kQ}{r}$ ⟶ outside

$V = \frac{kQ}{2a^3}(3a^2 - r^2)$ ⟶ inside

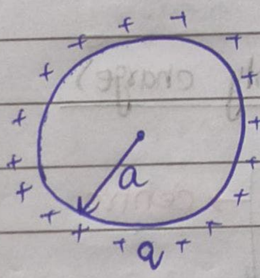


Q,a

SELF ENERGY

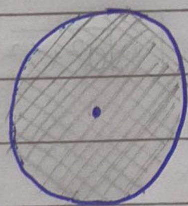
→ Uniformly charged hollow sphere –

$$\boxed{U = \frac{kQ^2}{2a}}$$



→ Uniformly charged non-conducting solid sphere –

$$\boxed{U = \frac{3}{5} \cdot \frac{kQ^2}{a}}$$



$$\boxed{U_{total} = U_{self\ energy} + U_{interaction}}$$

Energy Density

$$\boxed{\frac{du}{dv} = \frac{1}{2}\varepsilon E^2}$$

FLUX

↳ Total no. of field lines crossing through a surface.

$$\boxed{\phi = \int \vec{E} \cdot d\vec{s}}$$

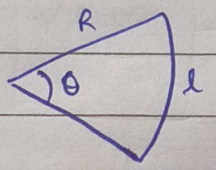
If E is uniform → $\phi = E \times \underbrace{\text{projected Area}}_{\text{Area} \perp \text{ to } \vec{E}}$

GAUSS LAW

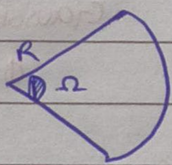
$$\boxed{\oint \vec{E} \cdot d\vec{s} = \frac{Q_{in}}{\varepsilon_0}} = \phi_{\text{closed surface}}$$

SOLID ANGLE

2D



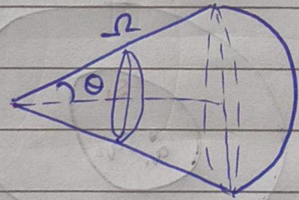
3D



$$\Omega = \frac{S}{R^2}$$

$$\boxed{\theta = l/R \text{ rads}}$$

$$\boxed{\Omega = 2\pi(1 - \cos\theta)}$$



Total 3D angle of
Complete 3D sphere = 4π

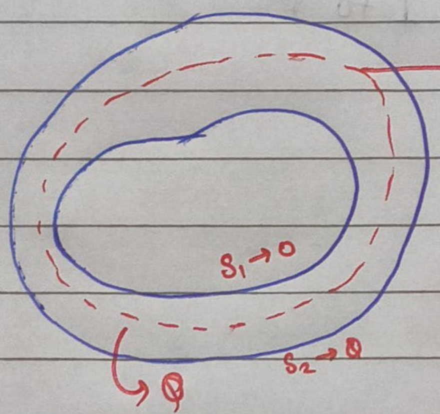
CONDUCTORS

$dV = -\vec{E} \cdot d\vec{r}$ } → $dV = 0$ ⇒ $V = 0$ ∴ Entire conductor body is equipotential.
& $E = 0$

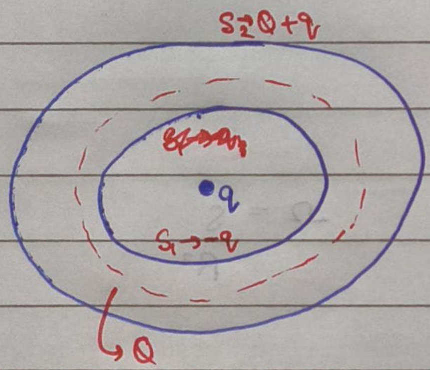
$$\boxed{E = \frac{\sigma}{\varepsilon_0}}$$ → σ is local charge density
E is field near conductor surface.

$$\boxed{P = \frac{\sigma^2}{2\varepsilon_0}}$$ → Electric pressure on conductor's surface.

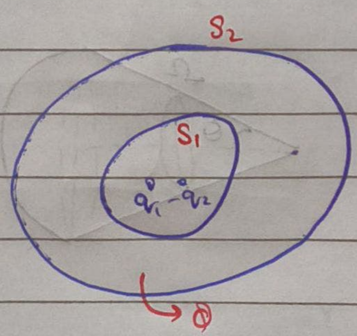
SOME IMP INFO ABT CONDUCTOR W/ CAVITY.



→ Gaussian surface:
E = 0 everywhere
$\Phi = 0$ & $q_{in} = 0$



∴ $S_1 + S_2 = Q$
Gaussian surface:
$\Phi = 0$ & $q_{in} = 0$



$S_1 \to -q_1 + q_2$
$S_2 \to Q + q_1 - q_2$

⇒ E_{net} outside S_1 due to charges INSIDE S_1 is zero.
↳ same for V_{net}

⇒ E_{net} inside S_2 due to charges OUTSIDE S_2 is zero
↳ For V_{net} it is const (not necessarily zero)