Electrostatics

water
$k = 81$

① Induced charge $q' = -Q\left(1-\frac{1}{k}\right)$ $\boxed{E' = E(1-1/k)}$

② $\boxed{F = kQ_1Q_2/r^2}$

relative permittivity or dielectric const

③ $\boxed{K = \frac{\varepsilon_{medium}}{\varepsilon_0}}$ $\boxed{K = \frac{F_{air}}{F_{med}}}$

for multiple dielectric

④ $\boxed{F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{(r_{eff})^2}}$ $\boxed{r_{eff} = \sqrt{k}\, r}$

⑤ equilibrium of angle

a) b/w like charges $\boxed{x = \frac{\sqrt{Q_1}\, r}{\sqrt{Q_1}+\sqrt{Q_2}}}$

b) b/w unlike charges $\boxed{x = \frac{\sqrt{Q_1}\, r}{\sqrt{Q_1}-\sqrt{Q_2}}}$

⑥ Electric field $\boxed{E = \frac{kQ}{r^2}}$ $\boxed{= \frac{F}{q_0}}$

in vector form:

$$\boxed{\vec{E} = \frac{kQ}{r^3}(\vec{r})}$$

⑦ E.F. at centre of circular arc

$$\boxed{E = \frac{2k\lambda}{r}\sin\left(\frac{\theta}{2}\right)} \to \text{for all conditions.}$$

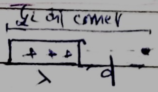
$r \to$ ⊥ for Rod always.

a) Infinite length rod $\boxed{E = \frac{2k\lambda}{r}}$

$\Delta V = 2k\lambda \log_e \frac{r_i}{r_f}$ ←

b) semi-infinite Rod $\boxed{E = \frac{k\lambda}{r}}$

⑧ field on axis of Rod

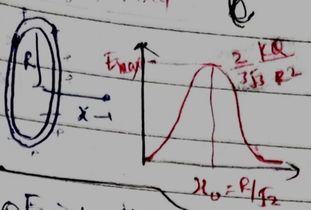


$$E = k\lambda\left[\frac{1}{\text{पास का corner}} - \frac{1}{\text{दूर का corner}}\right]$$

or $\boxed{E = \frac{k\lambda}{\text{total distance } (d+l)}}$

E

① charged Ring



must learn

① $\boxed{E_{axial} = \frac{kqx}{(R^2+x^2)^{3/2}}}$ → equatorial in dipole

② $E_{centre} = 0$

③ $E_\infty = 0$

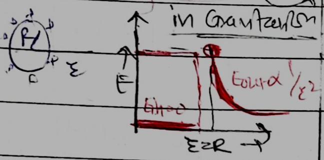
$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{mr^3}{kQQ_0}}$$

ring

-axial से per होगा double
$2\pi\sqrt{\frac{mr^3}{2kQQ_0}}$

② conducting sphere shell

in Gravitation

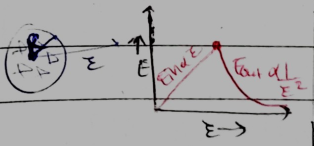


① outside pt ; $(r>R) \Rightarrow \frac{kQ}{r^2}$

② Just outside $\boxed{kQ/R^2}$

③ Just inside $(r<R) = 0$

③ Non-conducting sphere



① outside $= \frac{kQ}{r^2}$ $\boxed{\frac{E_s R^2}{r^2}}$

② on surface (max) $\boxed{\frac{kQ}{R^2}}$

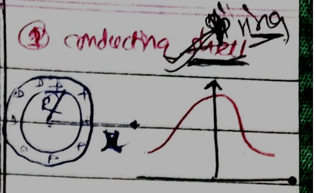
③ Inside $\boxed{E_{in} = \frac{E_s \cdot r}{R}}$

④ cavity in non conducting sphere

$$\vec{E} = \frac{\rho\vec{d}}{3\varepsilon_0}$$

V

① conducting ~~shell~~ ring



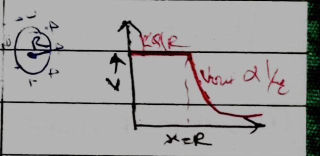
① ~~outside pt~~ $(r>R) \Rightarrow \frac{kQ}{r^2}$

① $V_{axial} = \frac{kQ}{(R^2+x^2)^{1/2}}$

② V_{centre} = max $\boxed{\frac{kQ}{R}}$

③ At ∞ dist ⇒ 0

② conducting sphere

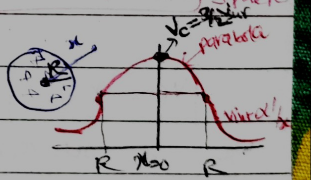


① outside $(x>R) \Rightarrow \boxed{kQ/x}$

② on the surface ⇒ kQ/R

③ Inside $= kQ/R$ → const

③ Non-conducting sphere

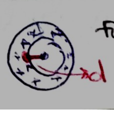


① outside $= \frac{kQ}{x}$

② on surface $= kQ/R$ (max)

③ Inside $\boxed{V_{in} = \frac{V_s(3R^2-x^2)}{2R^2}}$

④ at centre $\boxed{V_c = \frac{3}{2}V_{surface}}$



For cylinder $\vec{E} = \frac{\rho\vec{d}}{2\varepsilon_0}$

~~N~~conservative ∄ not path dependent → imp
eq ~~P~~otential (ΔV)

⑨ Electric flux

enclosed

$$d\phi = \vec{E}.\vec{ds} = E\,ds\cos\theta = \boxed{EA\cos\theta} = \boxed{\frac{q}{\varepsilon_0}}$$

⑩ flux of curved surface

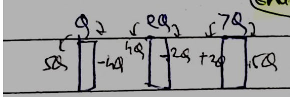
Gauss th.

$\phi_c = EA\cos\theta$

$\phi_{Total} = \phi_{curved} + \phi$ circular surface

⑪ conducting sheet $E = \sigma/\varepsilon_0$

⑫ Thin ~~non-conducting~~ charged sheet : $E = \sigma/2\varepsilon_0$



potential energy → scalar quantity.

$W_c = -\Delta U$	$q_0\Delta V$	$q_0 E.r$	$= F.r$

① system of charges
No. of pair = $\frac{n(n-1)}{2}$

$(U_{12} + U_{23} + U_{34} ----etc)$

② Arrangement & Rearrangement of sys.

$$\boxed{W_{ag} = -W_c = U_f - U_i = KQ_1Q_2\left(\frac{1}{r_2} - \frac{1}{r_1}\right)}$$

③ P.d and potential due to point charge.

$$\Delta V = \frac{\Delta U}{q_0} = \frac{\Delta W}{q_0} = KQ\left[\frac{1}{r_2} - \frac{1}{r_1}\right]$$

$$\boxed{V_P = KQ/r}$$

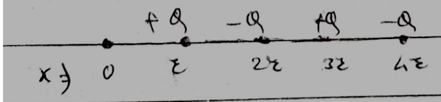
movable charge

$$W_{aq} = -W_c = \Delta U = q_0\Delta V = q_0[V_f - V_i]$$

P.d. due to fixed charge at final & initial point

④ when charge is released

$$\boxed{K_i - K_f = U_f - U_i = \Delta U = q_0\Delta V}$$

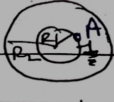


$$\boxed{V_P = \frac{KQ}{r}\log_e 2}$$

⑤ P.d. due to charged Rod

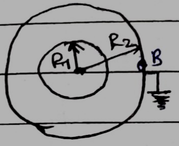
$$\boxed{\Delta V = 2K\lambda\log_e\frac{r_i}{r_f}}$$

⑥ Earthing

①


$$V_A = \frac{kq_1}{R_1} + \frac{kQ_2}{R_2} = 0$$

$$\boxed{q_1 = -\frac{R_1}{R_2}Q_2}$$

②


$$V_B = \frac{KQ_1}{R_2} + \frac{KQ_2}{R_2} = 0$$

$$\boxed{Q_2 = -Q_1}$$

⑦ charge distribution

$q_1F = \frac{R_1}{(R_1+R_2)}(Q_1+Q_2)$ $\boxed{Q \propto R}$	$q_{2f} = \frac{R_2}{(R_1+R_2)}(Q_1+Q_2)$

In current electricity. (Voltage distribution)

$$V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2} \Rightarrow \frac{4\pi\varepsilon_0(R_1+R_2)(V_1+V_2)}{4\pi\varepsilon_0(R_1+R_2)}$$

$$\therefore \boxed{V = \frac{R_1V_1 + R_2V_2}{R_1+R_2}}$$ $C = 4\pi\varepsilon_0 R$

Relⁿ b/w E and V

① $\boxed{E = -dV/dr}$ $\boxed{\Delta V = -\vec{E}.\vec{\Delta r}}$

② cartesian function

$$\vec{E} = -\frac{dU}{dx}\hat{i} - \frac{\partial U}{dy}\hat{j} - \frac{dU}{\partial z}\hat{k}$$

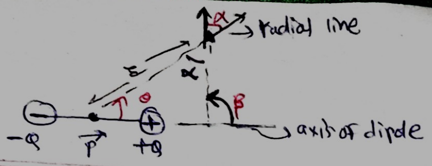
③ E. dipole $\boxed{P = q \times r}$

④ Field / potential due to short dipole.

① $E_{axial} = \frac{2KP}{r^3}$ $V_{axial} = \pm\frac{KP}{r^2}$

② $E_{eq} = \frac{-KP}{r^3}$ $V_{eq} = 0$

③ $\boxed{\vec{E}_{axial} = -2E_{eq}}$



Ⓐ General point

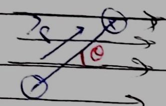
$$\boxed{E_N = \frac{kp}{r^3}\sqrt{3\cos^2\theta + 1}}$$

$$\boxed{V = \frac{kp\cos\theta}{r^2}}$$

$$\boxed{\beta = \theta + \alpha} \Rightarrow \boxed{\theta + \tan^{-1}(1/2\tan\theta)}$$

$$\boxed{\tan\alpha = 1/2 \tan\theta}$$

⑤ torque, P.E and work done in uniform field.



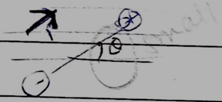
① $\boxed{\tau = pE.\sin\theta = I\alpha}$ angular acclⁿ

$I = m_{red}\, r^2$ $\boxed{m_{red} = \frac{m_1 * m_2}{m_1 + m_2}}$

② $\boxed{U = -p.E\cos\theta}$ — U zero then Torque (max)

— Torque is zero, when U_{min} & U_{max}

⑥ S.H.M of dipole



$$\boxed{T = 2\pi\sqrt{\frac{I}{p.E}}}$$

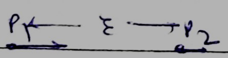
E.field

dipole moment

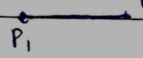
③ $W_{ag} = PE[\cos\theta_1 - \cos\theta_2]$

$\theta = 180° \Rightarrow$ $\boxed{W_{max} = 2PE \Rightarrow 2\tau_{max}}$

Ⓐ Force b/w dipole – dipole in non-uniform field.



⇒ ① ~~PE~~.



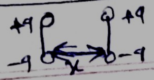
$E_1 = \frac{2kp_1}{r^3}$

② τ = zero, (here)

③ $U = -P_2E_1\cos 0° \Rightarrow -P_2E_1$

④ $F = \frac{-dU}{dr} \Rightarrow \boxed{P_2\left(\frac{dE_1}{dr}\right)}$

Force b/w 2 dipoles ⇒ $\boxed{F = \frac{1}{4\pi\varepsilon_0}\frac{3P_1P_2}{x^4}}$



✱ Flux goes in pyramid : $\boxed{q/2\varepsilon_0}$

flux inward ⇒ −ve

flux outward ⇒ +ve.

$E_{axis} = \frac{2kpx}{(x^2 - a^2)^2}$ $\boxed{x >>> a} = \frac{2kp}{x^3}$

$$\boxed{E_{eq} = -\frac{kp}{(x^2 + a^2)^{3/2}}}$$ $x >>> a$ $\boxed{-\frac{kp}{x^3}}$

$\boxed{T = 2\pi\sqrt{\frac{I}{MB}}}$ ⇒ vibration magnetometer