PHYSICS by
RAJAT SACHDEV
(B Sc, M Sc, B.Ed.)
M. 9580951094

PAGE NO.
DATE: / /

Electric Potential

1) **Electrostatic Potential** :- The work done to bring any ~~two~~ +ve charge from infinity to any point in the electric field is called electrostatic potential.

$$V = \frac{W}{q_0}$$

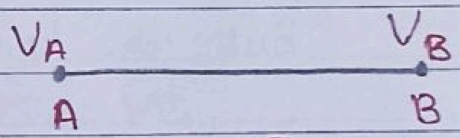
unit - Joule / Coulomb or volt.

Dim - $\frac{[ML^2T^{-2}]}{[AT]}$

$= [ML^2T^{-3}A^{-1}]$

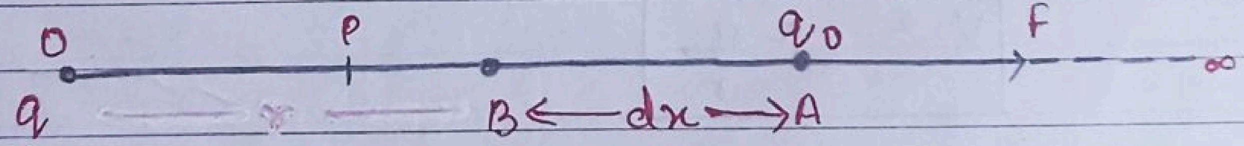
2) **Electric Potential difference** :- From one point to another.

$$V_B - V_A = \frac{W_{AB}}{q_0}$$



$\Rightarrow$ dim. - $[ML^2T^{-3}A^{-1}]$

3) **Electric Potential due to point charge**



$$F = \frac{1}{4\pi\varepsilon_0}\frac{q q_0}{x^2}$$

Work done to bring a charge from A to B,

$$dW = \vec{F} \cdot \vec{dx}$$
$$= F\,dx \cos 180^\circ$$
$$dW = -F\,dx$$

Work done

$$W = \int dW = -\int_{\infty}^{r} F\,dx$$

$$= -\int_{\infty}^{r} \frac{1}{4\pi\varepsilon_0} \frac{q q_0}{x^2} \cdot dx$$

$$= -\frac{1}{4\pi\varepsilon_0} q q_0 \left[-\frac{1}{x}\right]_{\infty}^{r}$$

$$= \frac{-1}{4\pi\varepsilon_0} q q_0 \left[-\frac{1}{x}\right]_{\infty}^{r}$$

$$= \frac{1}{4\pi\varepsilon_0} q q_0 \left[\frac{1}{r} - \frac{1}{\infty}\right]$$

$$\boxed{W = \frac{1}{4\pi\varepsilon_0} \frac{q q_0}{r}}$$

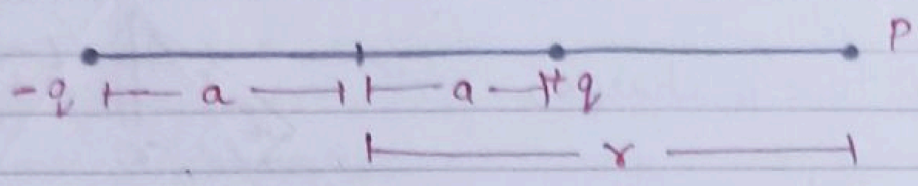
But we know, $V = \frac{W}{q_0}$

$$V = \frac{\frac{1}{4\pi\varepsilon_0} \frac{q \cancel{q_0}}{r}}{\cancel{q_0}}$$

$$\boxed{V = k\frac{q}{r}}$$

RAJAT SIR PHYSICS NOTES

Electric Potential due to axial Electric dipole



Potential due to q charge,

$$V_{-q} = \frac{1}{4\pi\varepsilon_0} \frac{-q}{r+a} = \frac{1}{4\pi\varepsilon_0} \frac{q}{r+a}$$

$$V_{+q} = \frac{1}{4\pi\varepsilon_0} \frac{q}{r-a}$$

Total Potential, $V = V_{-q} - V_{+q}$

$$V = \frac{1}{4\pi\varepsilon_0} \frac{q}{r+a} - \frac{1}{4\pi\varepsilon_0} \frac{q}{r-a}$$

$$= \frac{1}{4\pi\varepsilon_0} q \left[\frac{1}{r+a} - \frac{1}{r-a} \right]$$

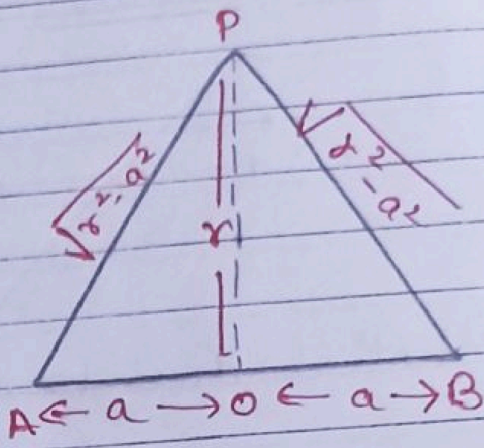
$$= \frac{1}{4\pi\varepsilon_0} q \left[\frac{r-a-r+a}{r^2-a^2} \right]$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2-a^2}$$

If $r >>>> a$, then $a = -ve$

$$\boxed{V = k \frac{q}{r^2}}$$

RAJAT SIR PHYSICS NOTES



Equatorial Position

Due to −q charge,

$$V_{-q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{\sqrt{r^2-a^2}}$$

$$V_{+q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{\sqrt{r^2-q^2}}$$

$$V = V_{-q} + V_{+q}$$

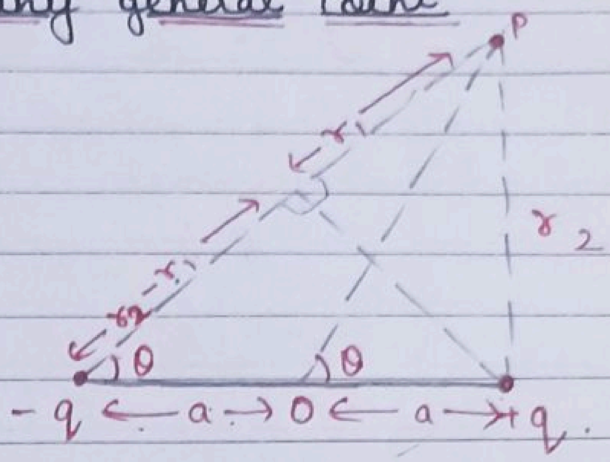
$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{\sqrt{r^2-a^2}} - \frac{1}{4\pi\varepsilon_0}\frac{q}{\sqrt{r^2-a^2}}$$

$$= \frac{1}{4\pi\varepsilon_0} q\left[\frac{1}{\sqrt{r^2-a^2}} - \frac{1}{\sqrt{r^2-a^2}}\right]$$

$$V = 0$$

RAJAT SIR PHYSICS NOTES

Electric Potential due to any general Point



$$V = \frac{1}{4\pi\varepsilon_0} q \left[\frac{1}{r_2} - \frac{1}{r_1} \right]$$

$$V = \frac{1}{4\pi\varepsilon_0} q \left[\frac{r_1 - r_2}{r_2 r_1} \right]$$

$$r_1 \approx r_2$$

$$\cos\theta = \frac{r_1 - r_2}{2a}$$

$$r_1 - r_2 = 2a\cos\theta$$

$$V = \frac{1}{4\pi\varepsilon_0} q \frac{2a\cos\theta}{r^2}$$

$$\boxed{V = \frac{1}{4\pi\varepsilon_0} \frac{P\cos\theta}{r^2}}$$

$\because P = 2aq$

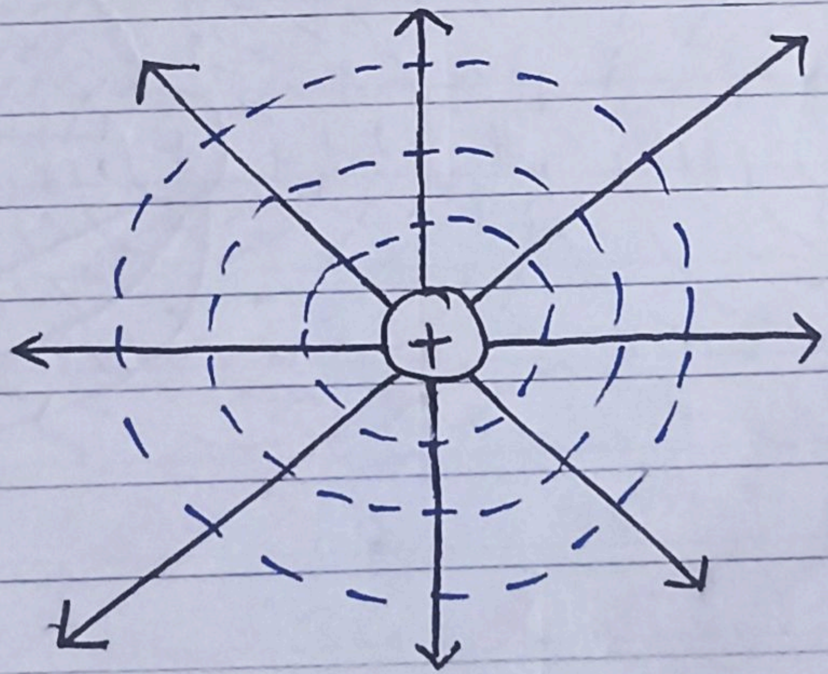
$$\boxed{V = k \frac{P r \cos\theta}{r^3}}$$

$$\boxed{V = k \cdot \frac{\vec{P} \cdot \vec{r}}{r^3}}$$

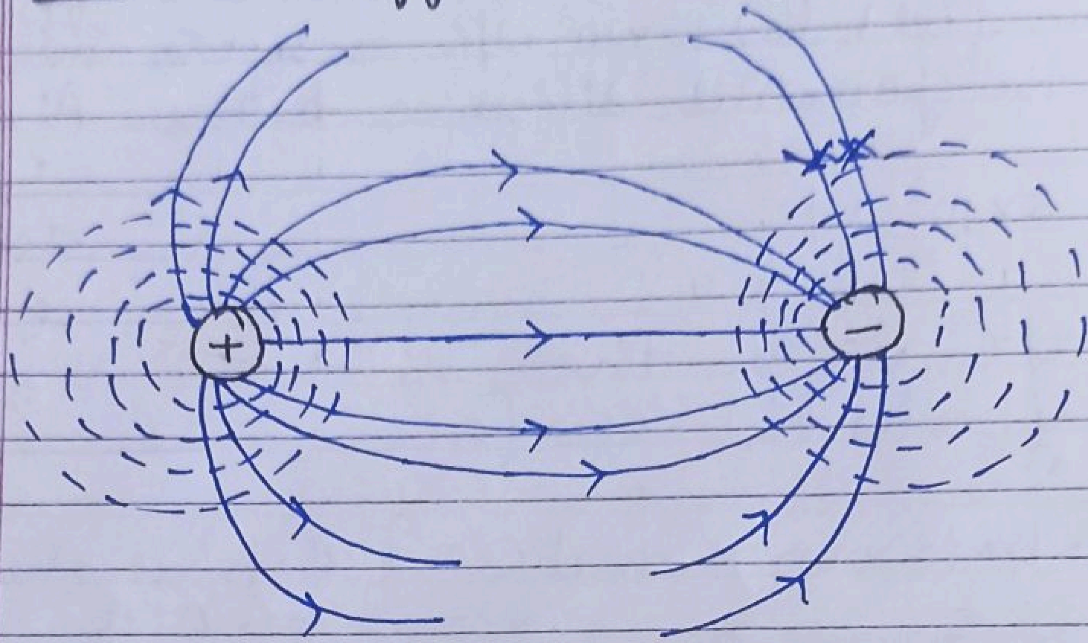
1.

Potential of different charges

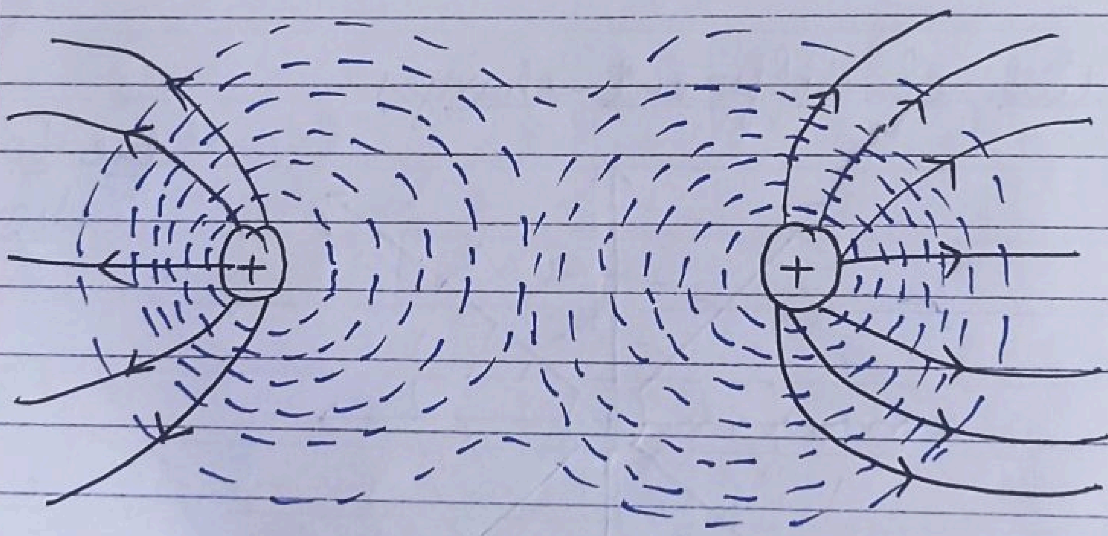
due to position charge.



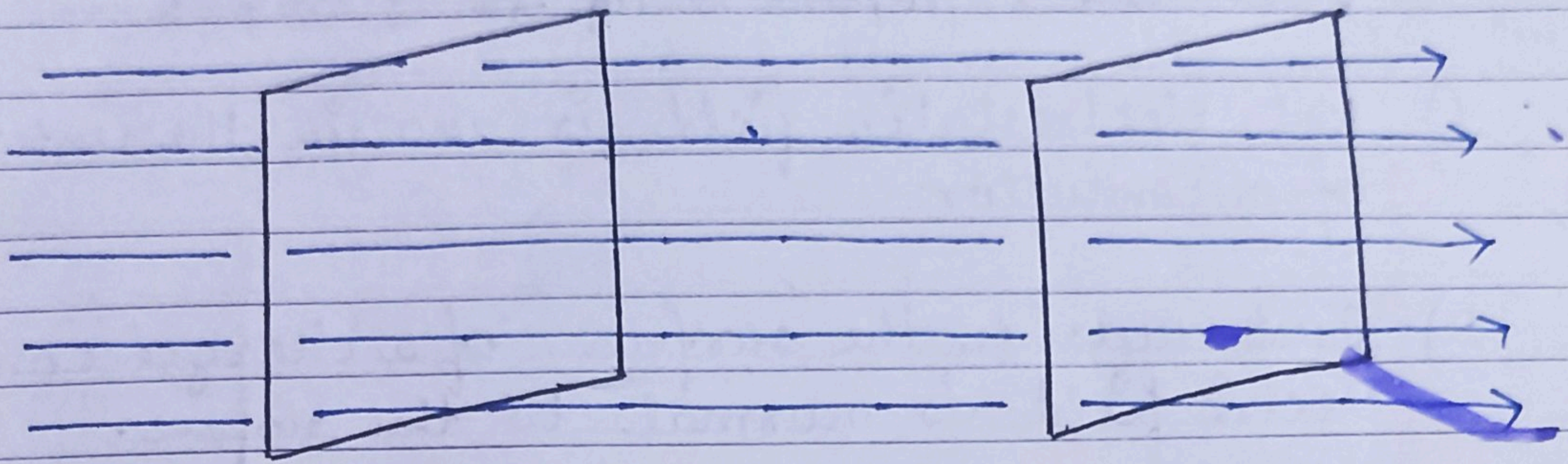
Due to different charge



Due to positive charge



Due to infinite plane sheet



RAJAT SIR PHYSICS NOTES

PHYSICS by
RAJAT SACHDEV
(B Sc. M Sc. B Ed)
M. 9588961094

PAGE NO.
DATE:

Nu

Electrostatic properties of a conductor

1) Net electrostatic field is zero in the interior of a conductor

2) Just outside the surface of a charged conductor electric field is normal to the surface.

3) The net charge in the interior of conductor is zero at any excess charge resides at its surface.

4) Potential is constant within and on the surface of the conductor.

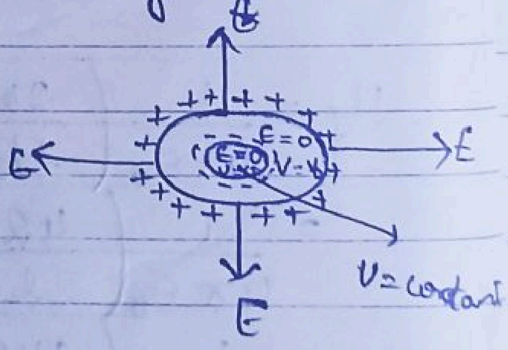
5) Electric field at the surface of a charged conductor is proportional to the surface charge density.

$$E \propto \sigma$$

6) Electric field is zero in the cavity of a hollow charged conductor

$$E = -\frac{dV}{dr} \qquad E = 0$$

$$\frac{dV}{dr} = 0 \qquad V = \text{constant}$$



Electrical Capacitance of Conductor

The ability of a conductor to store the ~~charge~~ charge is called Capacitance.

$$Q \propto V$$

$$Q = CV$$

$$\boxed{C = \frac{Q}{V} = \frac{\text{Charge}}{\text{Volt}}}$$

Unit $\rightarrow \frac{\text{Coulomb}}{\text{Volt}}$ = Farad.

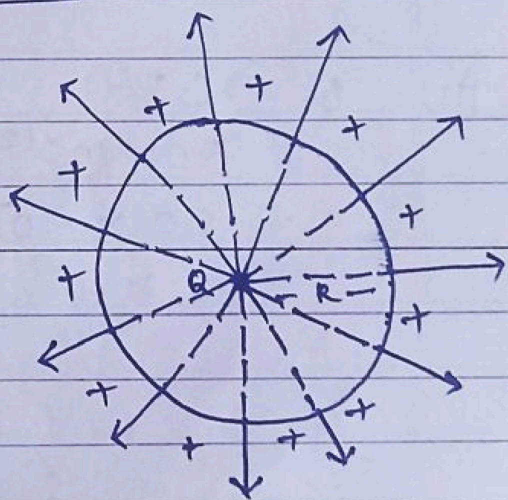
Dim $\rightarrow \frac{[AT]}{[ML^2T^{-3}A^{-1}]} = [M^{-1}L^{-2}T^4A^2]$

Capacitance of an isolated Spherical ~~Capacitance~~ Capacitor

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$$

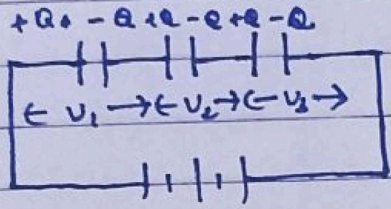
$$C = \frac{Q}{V} = \frac{Q}{\frac{1}{4\pi\varepsilon_0}\frac{Q}{R}}$$

$$\boxed{C = 4\pi\varepsilon_0 R}$$



Combination of Capacitance

1) In series :-



Net Potential

$$V = V_1 + V_2 + V_3$$

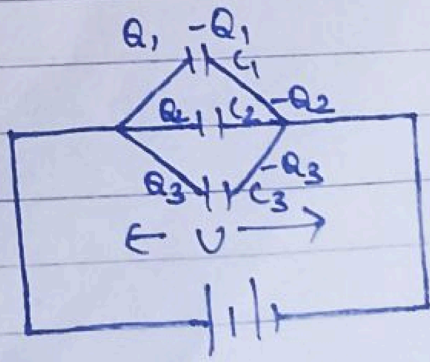
$$V = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$V = Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

$$\frac{V}{Q} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

$$\boxed{\frac{1}{C} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)}$$

In Parallel,



$$Q = Q_1 + Q_2 + Q_3$$

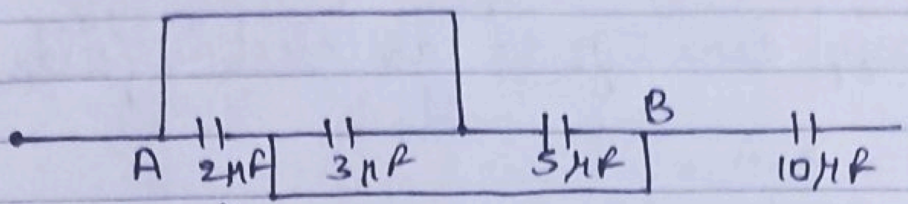
$$Q = C_1V + C_2V + C_3V$$

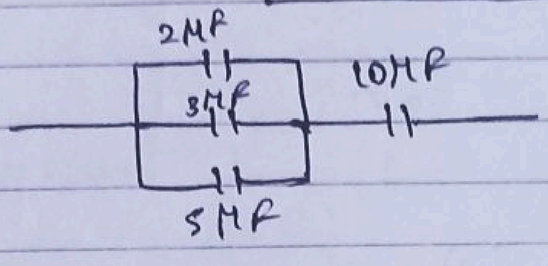
$$Q = V(C_1 + C_2 + C_3)$$

$$\frac{Q}{V} = C_1 + C_2 + C_3$$

$$\boxed{C = C_1 + C_2 + C_3}$$

Ques)

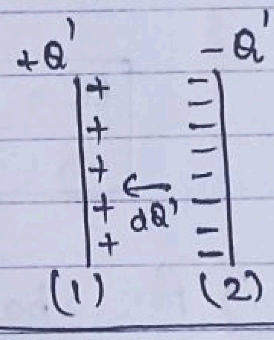




$\Rightarrow 2 + 3 + 5\ \mu F = 10\mu F$

$\frac{1}{C} = \frac{1}{10} + \frac{1}{10}\ \mu F = 5\ \mu F$

Energy stored in capacitors



$V' = \frac{Q'}{C}$

$dW = V' dQ'$

$= \frac{Q'}{C} dQ'$

total work done,

$W = \int dW = \frac{1}{2}\int_0^Q Q' dQ'$

$= \frac{1}{2}\left[\frac{Q'^2}{2}\right]_0^Q$

$$U = W = \frac{1}{2}\frac{Q^2}{C}$$

$Q = CV$

$$U = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

In series,

$U = \frac{Q^2}{2}\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots\right]$

$= \frac{Q^2}{2C_1} + \frac{Q^2}{2C_2} + \frac{Q^2}{2C_3} + \dots$

$$U = U_1 + U_2 + U_3 + \dots$$

In parallel,

$U = \frac{1}{2}V^2(C_1 + C_2 + C_3 + \dots$

$U = \frac{1}{2}C_1V^2 + \frac{1}{2}C_2V^2 + \frac{1}{2}C_3V$

$$U = U_1 + U_2 + U_3 + \dots$$

RAJAT SIR PHYSICS NOTES

PAGE NO.
DATE:

Energy density of an electric field.

$$C = \frac{\varepsilon_0 A}{d}$$

$$E = \frac{\sigma}{\varepsilon_0} \Rightarrow \sigma = \varepsilon_0 E$$

$$Q = \sigma A = \varepsilon_0 E A$$

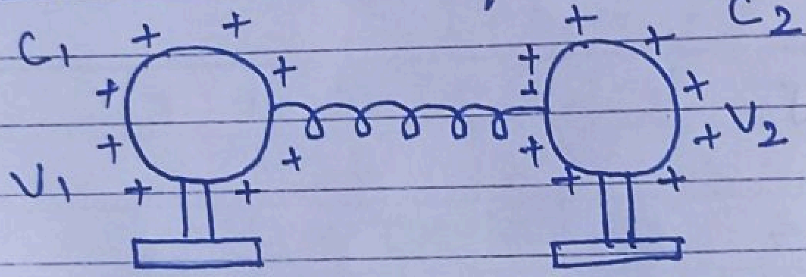
$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{\varepsilon_0^2 E^2 A^2 d}{\varepsilon_0 A}$$

$$U = \frac{1}{2}\varepsilon_0 E^2 A d$$

$$\boxed{u = \frac{U}{Ad} = \frac{1}{2}\varepsilon_0 E^2}$$

RAJAT SIR PHYSICS NOTES

Redistribution of Charges



$Q_1 = C_1V_1$, $Q_2 = C_2V_2$

Common Potential = $\dfrac{\text{total charge}}{\text{total capacitance}}$

$$V = \frac{Q_1 + Q_2}{C_1 + C_2}$$

$$\boxed{V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}}$$

$Q_1' = C_1V$

$Q_2' = C_2V$

$$\boxed{\frac{Q_1'}{Q_2'} = \frac{C_1}{C_2}}$$