Lecture 1

Charge : Intrinsic Property of matter.

- Firstly Benjamin Franklin discovered charges
- He conducted a series of experiments. that similar ~~ar~~ repels and opposite attracts.
- Rubber Rod —— Silk
  Glass Rod —— Fur

Columb's Law :

$$F = k \frac{q_1 q_2}{r^2}$$

or,

$$F = \frac{1}{4\pi \varepsilon_0} \frac{q_1 q_2}{r^2}$$

With Medium

$$F' = \frac{1}{4\pi \varepsilon} \frac{q_1 q_2}{r^2}$$

$$F' = \frac{1}{4\pi \varepsilon_0} \frac{q_1 q_2}{r^2} \left(\frac{1}{\varepsilon_r} \right) \quad \because \varepsilon = \varepsilon_0 \varepsilon_r$$

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Lecture 2

- Poori kainat in 4 forces pr based hai.
- 1) Gravitational Force 2) Strong force (Nuclear force)
  3) Electromagnetic force 4) Weak force.

Sample Problem 25-2

Data

$q_1 = 1.35 \times 10^5\ C$

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

$x = 100m$

$F = ?$

Solution

$$F = \frac{k q_1 q_2}{r^2} = 1.69 \times 10^6\ N$$

large force exists but not experienced

25.3

$x = 5.3 \times 10^{-11} m$

$$F_G = \frac{G m_1 m_2}{x^2} = 3.67 \times 10^{-47}\ N \text{ (very small)}$$

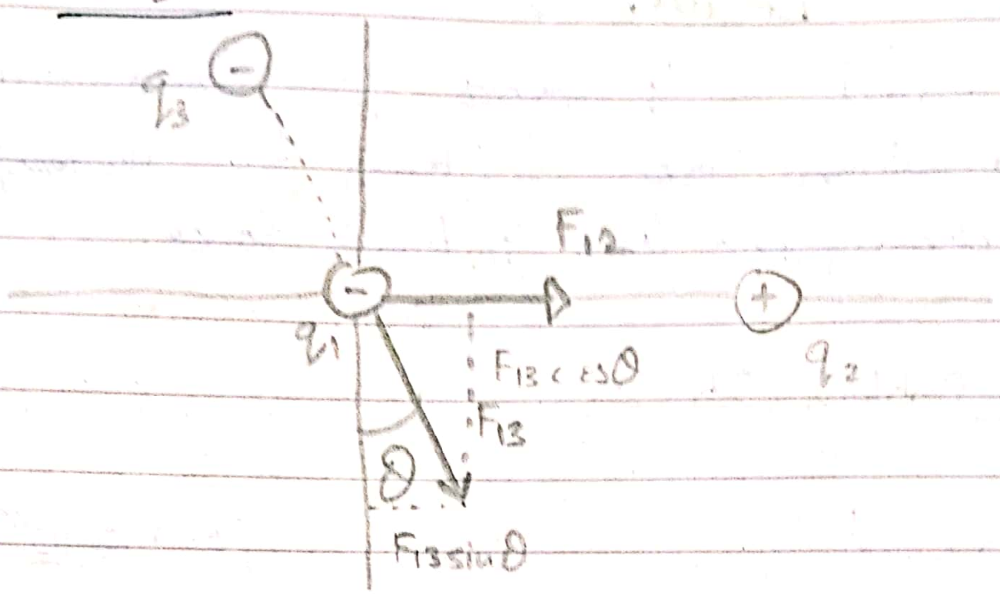
$$F_E = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_2}{x^2}\right) = 8.2 \times 10^{-8} N \text{ (very large)}$$

Here F_E is dominating

25.4

$$F_E = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} = 14N$$

25.5



$q_1 = -1.2\,\mu C$, $r_{12} = 15\,cm$

$q_2 = 3.7\,\mu C$, $r_{12} = 10\,cm$

$q_3 = -2.3\,\mu C$, $\theta = 32^\circ$

$$F_{13} = \frac{k\,q_1 q_2}{r_{13}^2} = 2.48\,N$$

$$F_{12} = \frac{k\,q_1 q_2}{r_{12}^2} = 1.77\,N$$

1 py 2 lga Nh

Forces along x

$$F_{1x} = F_{12} + F_{13}\sin\theta$$

$$= 1.77 + 2.49(\sin(32))$$

$$\boxed{F_{1x} = 3.08\,N}$$

Forces along y

$$F_{1y} = 0 + (-F_{13}\cos\theta) \quad \because -y \text{ axis}$$

$$\boxed{F_{1y} = -2.10\,N}$$

$$H^2 = B^2 + P^2$$

$$H = \sqrt{B^2 + P^2}$$

$$F_1 = \sqrt{(F_{1x})^2 + (F_{1y})^2} = \boxed{3.73N}$$

Field : Area around which we can experience force

Fields are of two Types :-

Scalar — Vector

Temp — $\vec{v}$ (Velocity)

- Static fields are plain
- Dynamic fields are in form of waves.

$$E = \frac{F}{q} \quad \text{same as} \quad g = \frac{W}{m}$$

- This formula means k aik aaise region jaha charge force experience kr rha ho.

Test Charge :

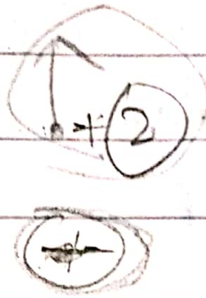
- It is an ideal charge (ONE)
- +ve always
- magnitude is 1.
- Does not disturb the field of another charge.

$$\therefore \vec{E} = \frac{\vec{F}}{q_0}$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{q\cancel{q_0}}{r^2} \cdot \frac{1}{\cancel{q_0}}$$

$$\boxed{E = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2}}$$

Units :- N/C <u>OR</u> V/m



Sample Problem 26

a) $E = \frac{F}{q_0}$ Here $q = -e$ and $F = 3.60 \times 10^{-8}$ N

$E = -2.25 \times 10^{11}$ N/C

b) Here $q = 2e$ (it is alpa hence +ve)

$F = qE$

$= (2e)(-2.25 \times 10^{11})$

$$\boxed{F = -7.20 \times 10^{-8} \text{ N}}$$

26.2

$E_r = ?$

He

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

$$= \frac{1}{4\pi\varepsilon_0} \frac{2(1.6 \times 10^{-19})}{26.5 \times 10^{-12}}$$

$E_p = 4.10 \times 10^{12}$ N/C

The electric field due to 2 charge at point P is $E = 4.10 \times 10^{12}$

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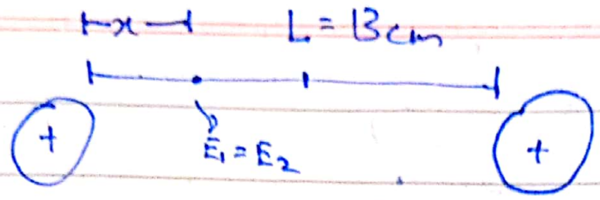
26.3



$q_1 = 1.5\,\mu C$ $\qquad$ $q_2 = 2.3\,\mu C$

$$\cancel{E = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{r^2}}$$

$$\cancel{0 = \frac{1}{4\pi\varepsilon_0} \frac{(1.5)(2.3)}{}}$$

$$E_1 = E_2$$

$$\frac{1}{4\pi\varepsilon_0}\frac{q_1}{x^2} = \frac{1}{4\pi\varepsilon_0}\frac{q_2}{(L-x)^2}$$

$$\frac{q_1}{x^2} = \frac{q_2}{(L-x)^2}$$

$$\frac{1.5\,\mu C}{x^2} = \frac{2.3\,\mu C}{L^2 - 2Lx + x^2}$$

$$1.5(169 - 26x + x^2) = 2.3x^2$$

$$253.5 - 39x + 1.5x^2 = 2.3x^2$$

$$2.3x^2 - 1.5x^2 + 39x - 253.5 = 0$$

$$0.8x^2 + 39x - 253.5 = 0$$

$$\frac{(L-x)}{x} = \pm\sqrt{\frac{q_2}{q_1}}$$

$$\frac{L}{x} - \frac{x}{x} = \pm\sqrt{\frac{q_2}{q_1}}$$

$$\frac{L}{x} - 1 = \pm\sqrt{\frac{2.3}{1.5}}$$

$$\frac{L}{x} - 1 = \pm 1.23827$$

$$\frac{L}{x} = -0.23827$$

$$\frac{13}{0.23827} = x$$

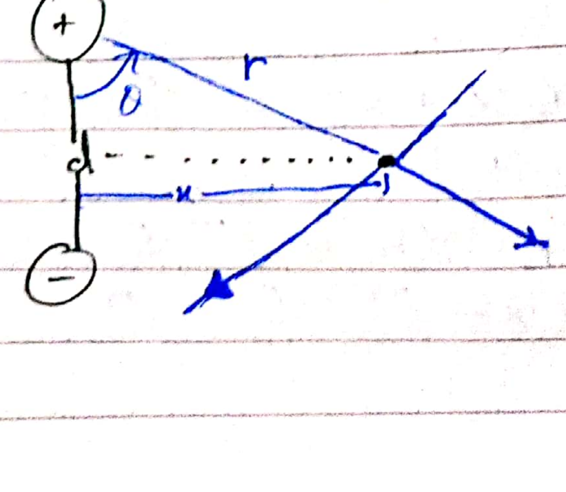
$$x = -54.55$$

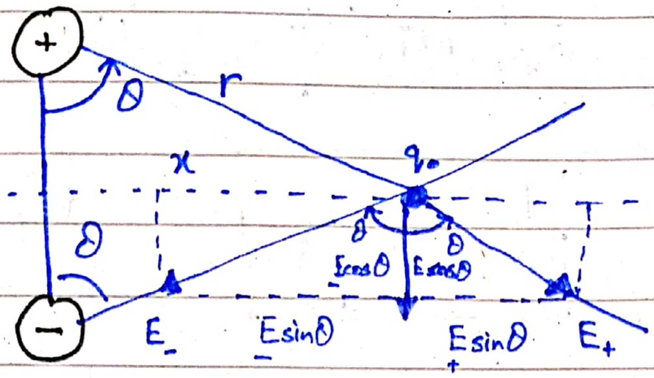
$$\frac{L}{x} = +2.238$$

$$\boxed{x = 5.8087}$$

Electric Dipole (p)

Formula = $p = qd$





here,

$$\boxed{E_-\sin\theta = E_+\sin\theta}$$

{cancels each others effect}

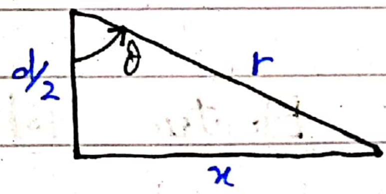
$$E = E_+\cos\theta + E_-\cos\theta$$

$$E_+ = E_- = E$$

then,

$$\boxed{E = 2E\cos\theta} \text{ ——— (i)}$$

We know that



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

$$= \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{x^2+(d/2)^2} \text{ ——— (ii)}$$

Putting (ii) in (i)

$$\text{(i)} \Rightarrow E = 2\left(\frac{1}{4\pi\varepsilon_0}\,\frac{q}{x^2+(d/2)^2}\right)\cos\theta$$

$$\because \cos\theta = \frac{b}{h}$$

$$E = \cancel{2}\left(\frac{1}{4\pi\varepsilon_0}\,\frac{q}{x^2+(d/2)^2}\right)\frac{d/\cancel{2}}{r}$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{\left[x^2 + \left(\frac{d}{2}\right)^2\right]} \cdot \frac{d}{\left[x^2 + \left(\frac{d}{2}\right)^2\right]^{1/2}}$$

$$\boxed{E = \frac{1}{4\pi\varepsilon_0} \frac{p}{\left[x^2 + \left(\frac{d}{2}\right)^2\right]^{3/2}}} \qquad \because p = qd$$

Conclusion: This is the electric field due to a dipole at perpendicular bisector.

- Electric field varies inversely with x^3
- Signature of electric dipole is $\boxed{E \propto \frac{1}{x^3}}$

if $x >>> d/2$

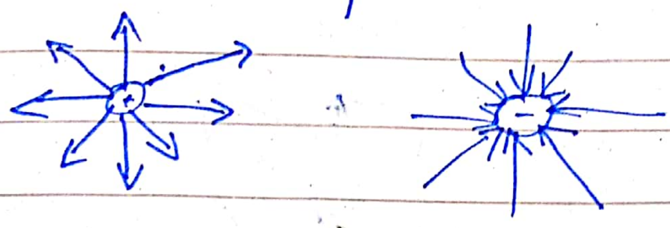
$E = \frac{1}{4\pi\varepsilon_0} \, p/(x^2)^{3/2}$

Electric Field Properties

1) The field is uniform when electric lines of forces are parallel. and its non-uniform when not parallel.

2) Electric field lines starts from positive and ends on negative.

3) If the density of electric lines increases the electric field increases. and vice versa.



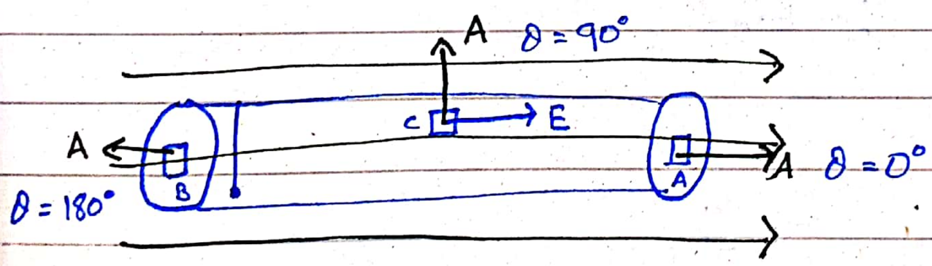
Gauss Law

- Flux means to flow through an area.

Flux = field · Area

$$\phi = \vec{f} \cdot \Delta\vec{A}$$

$$\boxed{\phi = F \Delta A \cos\theta}$$



Solution

$$\phi_E = E \cdot \Delta A$$

$$\phi_E = \phi_A + \phi_B + \phi_c$$

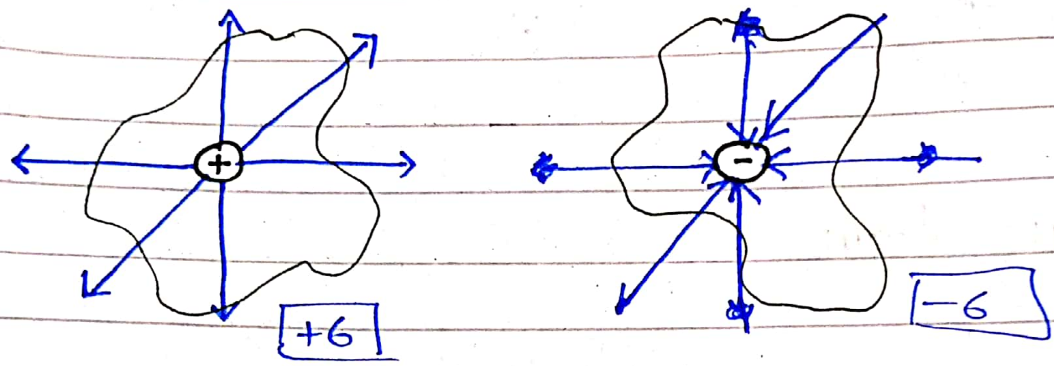
$$= E\Delta A_A \cos\theta + E\Delta A_B \cos\theta + E\Delta A_c \cos\theta$$

$$= E\Delta A_A \cos(0^\circ) + E\Delta A_B (180^\circ) + E\Delta A_c \cos(90^\circ)$$

$$= \cancel{E\Delta A} + \cancel{(-E\Delta A)} + 0$$

$$= 0 \quad (\text{For closed surface})$$

Flux and field lines



- +1 awarded when leaving surface
- -1 awarded when entering surface.

$$\phi_E = \frac{q_{enclosed}}{\varepsilon_0}$$

$$\oint \vec{E} \cdot \Delta\vec{A} = \frac{q_{en}}{\varepsilon_0}$$

Q) Which is more fundamental Guass Law or Columb's Law?

1) Guass Law
2) Why ?

Consider a sphere having charge q enclosed

$$\boxed{\oint E \cdot \Delta A = \frac{q}{\varepsilon_0}}$$

$$\cancel{E} \quad E(4\pi r^2) = \frac{q}{\varepsilon_0}$$

$$\boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}}$$ (Columb's Law)

We can derive Columb's law from Guass

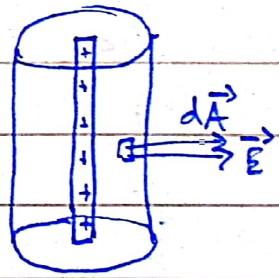
Applications Of Guass law :-

1) Infinite line of Charge

$\lambda = q/l$ = linear Charge density

$\sigma = q/A$ = Surface Charge density

$\rho = q/V$ = Volume Chrg Density



$$\oint E \cdot dA = q/\varepsilon_0$$

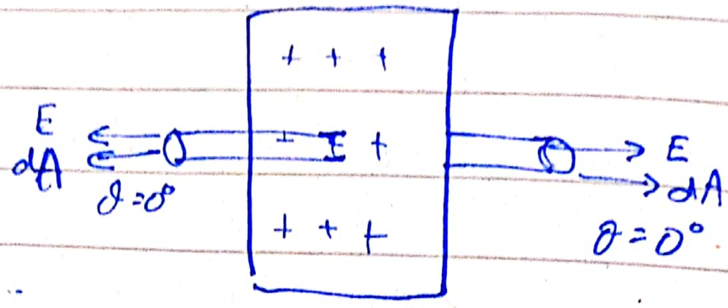
$$E(2\pi rh) = q/\varepsilon_0$$

$$E = \frac{q}{\varepsilon_0 2\pi rh} \Rightarrow \boxed{E = \frac{\lambda}{2\pi r\varepsilon_0}}$$

This is the formula for electric field due to infinite line of charge.

2) Infinite Sheet of Charge :

A/c to Guass



$$\oint E \cdot dA = q/\varepsilon_0$$

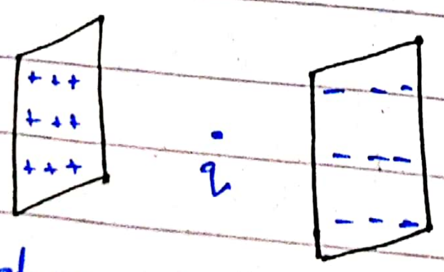
$$\oint_a E \cdot dA + \oint_b E dA = q/\varepsilon_0$$

$$EA + EA = q/\varepsilon_0$$

$$2EA = q/\varepsilon_0$$

$$E = \frac{q}{\varepsilon_0 2A}$$

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$



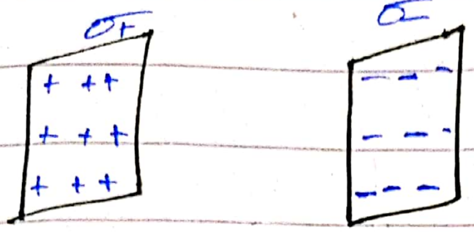
a) between

$$E = E_+ + E_-$$

$$= \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}$$

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

Sp 27.3



diff elec field

$\sigma_+ = 6.8 \mu C/m^2$
$\sigma_- = -4.3 \mu C/m^2$
$E_c = ?$, $E_L = ?$, $E_R = ?$

Solution

$\cancel{E_c}$

$$E_+ = \frac{\sigma}{2\varepsilon_0} = 3.84 \times 10^5 \; N/C$$

$$E_- = \frac{\sigma}{2\varepsilon_0} = 2.43 \times 10^5 \; N/C$$

$$E_c = E_+ + E_- = 5.91 \times 10^5 \; N/C$$
$$E_L = E_+ - E_- = 1.05 \times 10^5 \; N/C$$
$$E_R = E_+ - E_- = 1.05 \times 10^5 \; N/C$$

Electric Potential Energy

Δk = change in K.E
ΔU = change in P.E

Firstly, $F = \frac{G m_1 m_2}{r_2}$, $F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r_2}$

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Both follow inverse square law.

$$\Delta U = -W_{ab}$$

$$\Delta U = -\int_a^b F \cdot d\vec{r}$$

$$\Delta U' = -\int_a^b \frac{G m_1 m_2}{r^2} d\vec{r}$$

$$= + \frac{G m_1 m_2}{r^2}$$

$$\Delta U = G m_1 m_2 \left(\frac{1}{r_b} - \frac{1}{r_a} \right)$$

$$= 6.67 \times 10^{-11} \qquad m_1 m_2$$

Potential Energy

Formula

$$\Delta U = -\int \vec{F} \cdot \vec{ds} \quad \text{——— (i)}$$

For Electrostatic energy

$$F = \frac{1}{4\pi \varepsilon_0} \frac{q_1 q_2}{r^2} \quad \text{——— (ii)}$$

$$\Delta U = -\int_a^b \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \, dr$$

$$= -\frac{q_1 q_2}{4\pi\varepsilon_0} \int_a^b \frac{1}{r^2} \, dr$$

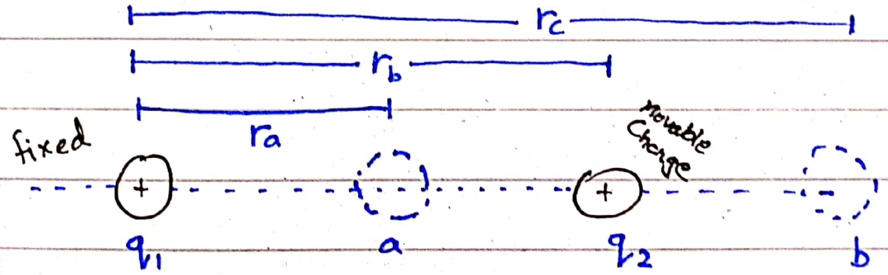
$$\boxed{\Delta U = \frac{1}{4\pi\varepsilon_0} q_1 q_2 \left(\frac{1}{r_b} - \frac{1}{r_a} \right)}$$

For change in P.E of electric field b/w 2 points A & B

- When you go against the gravitational or electric field you do some WORK.

Electric Potential Energy (   )

Case 1 (Similar Charges) (along - x)

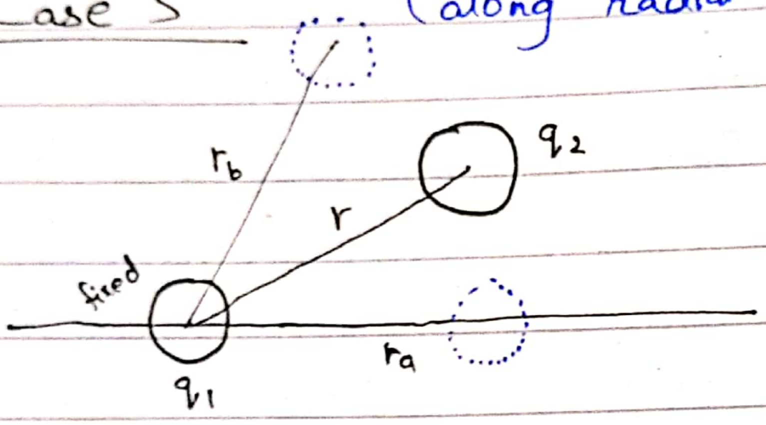


- b → a = Positive Work Done ; $\Delta U > 0$
- a → b = Negative Work Done ; $\Delta U < 0$

Case 2 (Dissimilar Charges) (along - x)

- $b \longrightarrow a$ = Negative Work Done ; $\Delta U < 0$
- $a \longrightarrow b$ = Positive Work Done ; $\Delta U > 0$

Case 3 (along radial line)



$$\Delta U = \frac{1}{4\pi\varepsilon_0} q_1 q_2 \left(\frac{1}{r_b} - \frac{1}{r_a} \right)$$

$\Delta U = 0$ $\quad \because \boxed{U_b = U_a}$

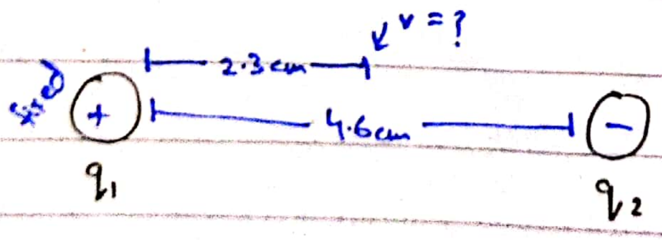
SP 28.2

Data

$m_1 = 0.0022\ kg$; $q_1 = 32\mu C$

$m_2 = 0.0039\ kg$; $q_2 = -18\mu C$

$x_i = 4.6\ cm = 0.046\ m$



Find : $V_{2.3} = ?$

Solution

Law Of Conservation of energy

$$\text{Before} = \text{After}$$

$$U_i + k_i = U_f + k_f$$

$$U_i + 0 = U_f + K_f$$

$$\therefore\ k_f = U_i + U_f$$

$$K_f = -\Delta U$$

$$K_f = -\left(\frac{1}{4\pi\varepsilon_0} q_1 q_2 \left(\frac{1}{x_f} - \frac{1}{x_i}\right)\right)$$

$$K_f = -\frac{1}{4\pi\varepsilon_0} q_1 q_2 \left(\frac{1}{0.023} - \frac{1}{0.046}\right)$$

$$\boxed{K_f = 113\ J}$$

WHY? m_2 : Bcz m_2 he tou move krha

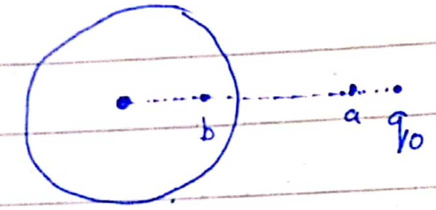
$$\frac{1}{2} m_2 v^2 = 113$$

$$\boxed{v = 240\ m/s}$$

Electric Potential / Voltage / Potential difference

$$\Delta V = \frac{\Delta U}{q_0} \quad \text{———} \quad (i)$$

$$V_b - V_a = \frac{U_b - U_a}{q_0} \quad \text{———} \quad (ii)$$



$$\Delta V = -\frac{W_{ab}}{q_0}$$

Absolute Electric Potential

$$V_b - 0 = \frac{U_b - 0}{q_0}$$

here a is a point at infinity

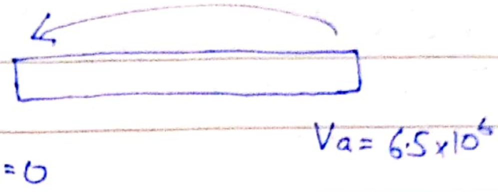
$$\boxed{V = \frac{U}{q_0}}$$

Alexandra Volta

Unit

$$1 \text{ volt} = \frac{1\,J}{1\,C}$$

SP 28.4



$V_a = 6.5 \times 10^6\ V$

$V_b = 0$

$\Delta U = ?$

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

Solution

$$\Delta V = \frac{\Delta U}{q_0}$$

$$\Delta U = (V_b - V_a)(2e)$$

$$\Delta U = \boxed{-2.1 \times 10^{-12}\ J}$$

$$\boxed{\Delta K = 2.1 \times 10^{-12}\ J}$$

Relationship between Voltage and Electric

We know that

$$\Delta V = -\frac{W_{ab}}{q_0} = -\int_a^b \frac{F}{q_0} \cdot ds$$

$$\Delta V = -\int E\, d\vec{s}$$

Table

	Vector	Scalar
Interaction two q	$F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{12}$	$\Delta U = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r}$
At one point	$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \hat{r}_{12}$	$V = \frac{1}{4\pi\varepsilon_0} \frac{q}{r}$

$$\boxed{E = \frac{F}{q_0}} \qquad \boxed{V = Ed}$$

$$\boxed{\Delta V = -\int_a^b \vec{E}\, d\vec{s}}$$

$$\Delta U = -\int_a^b \vec{F} \cdot d\vec{s} \qquad \Delta V = \frac{\Delta U}{q_0}$$

$\boxed{I \propto V}$ → Ohm's Law provided R, T and all the other quantities remains constant.

Q)

$I \propto V$

$I = kV$, $k = 1/R$

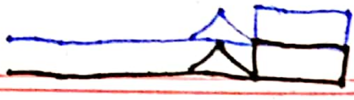
$\therefore$ $V = IR$

Resistance vs Resistivity

depends on material

Temperature

- Super Conductors
- Capacitor vs Resistance



Q) Why we using combination of Capacitors & Resistors in circuit

Q) AC vs DC.

Q) Agar Capacitor m se AC guzaru ya DC toa kia farq ?