15/3/19

Electrostatic

ई Branch of Physics in which we study about the phenominal of charge at rest condition.

Note → The rest condition of charge generate electric field.

Que → ① If charge is moving then how many field & waves are generate.

Sol →
$V = 0 \rightarrow E.F$

$V \rightarrow a = 0 \quad EF + MF$

$\quad \rightarrow a \neq 0 \quad EF + MF + EMW$

- **charge** → (Q) Intensive property of matter by which we can define electric field & Electrostatic force.

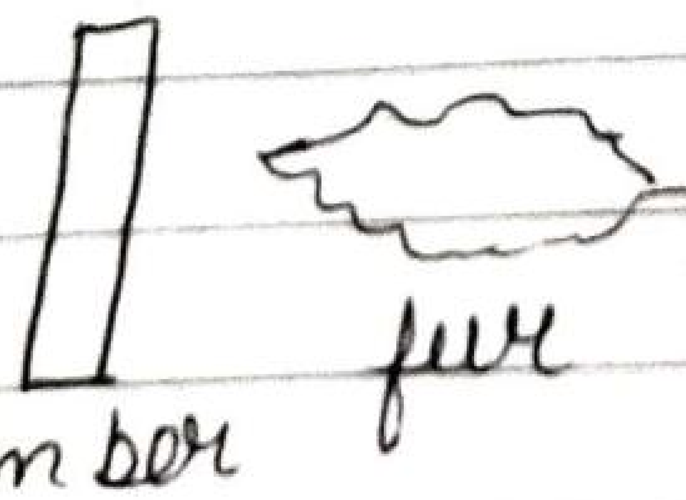
* Unit & Dimensions formula

$I = \frac{Q}{T} \Rightarrow Q = IT$

unit → $Q = A \times S$ = Coulamb

Dimension → $[M^0 L^0 T^1 A^1]$

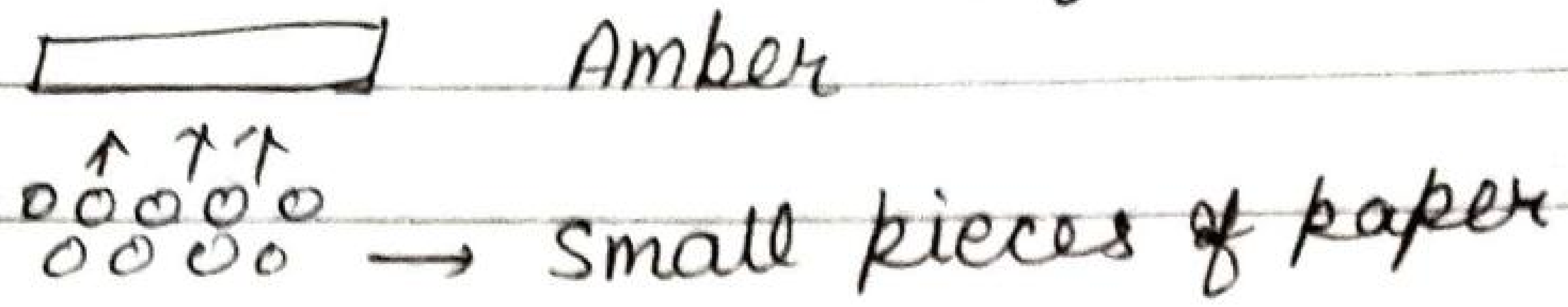
* History of charge - Charge is discovered by german scientist "Thelus" in 600 BC



Amber fur

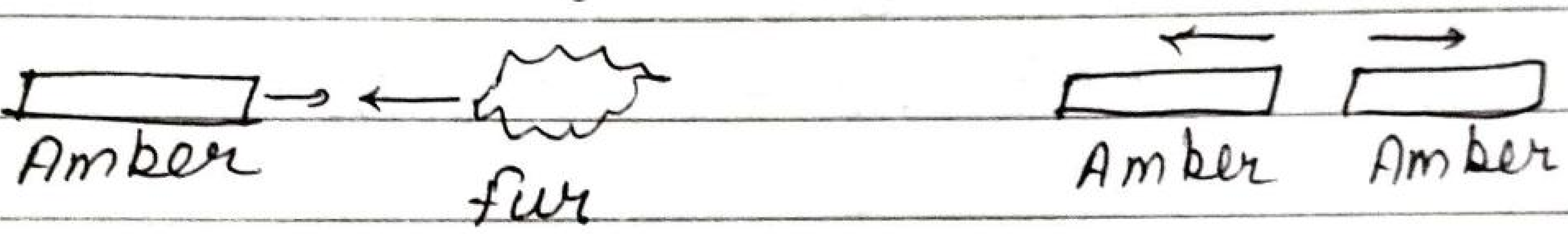
when Amber and fur are rubbed with each other.

→ Amber attract small pieces of paper.



✗ When amber attract the smaller pieces of paper then thelus say that Amber get a special physi property or Amber is electrified which is charg to charge body lefter.

→ Types of charge →



Attraction   Repulsion.

When fur & amber placed near each other they attract each other but when amber & amber placed near by then they repel each other.

→ On the behalf of this activity thelus conclude that
• like charge repel & unlike charge attract.

• Property of charge :—

Ⓐ Additivity of charge

Q_1, Q_2
Q_3, Q_4
Q_4

To find sum of charge—

$Q = Q_1 + Q_2 + Q_3 \cdots + Q_n$

Que-① Find total charge in given system.

Sol → $\Sigma Q = 3 - 2 + 3 + -7 = -3$ C.

$6 - 9 = -3$

Ⓑ Dependency on velocity → charge of a body does not depend upon velocity hence,

$$Q_{rest} = Q_{moving}$$

Note → Dependency of mass on speed

$$M_V = \frac{M_0}{\sqrt{1 - \frac{V^2}{C^2}}}$$

M_0 = Rest
V = velocity
C = speed of light

Ⓒ Quantization of charge → Charge is quantized activity which means charge always found in perfect multiplyers of e^-

$$Q = ne$$

e = charge of e^- $= 1.6 \times 10^{-19}$ C
n = no. of e^-

Que-① An object is charged by 2.56×10^{-17} C is it possible or not.

→ Yes it is = $Q = 2.56 \times 10^{-17}$ C

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

$$n = \frac{Q}{e} = \frac{2.56 \times 10^{-17} \times 10^1}{1.6 \times 10^{-19} \times 10^2} = 16 \times 10 = 160$$

~~Que-② If 190 e^- are transfer b/w two object then how much charge is transfer.~~

Que→② If 190 e^- are transfer b/w two object then how much charge is transfer.

→ $Q = 190 \times 1.6 \times 10^{-19} = 30.4 \times 10^{-18}$

Ⓓ Conservation of charge → charge is conserved quantity which means neither charge demolish nor generated can only transfer b/w 2 object.

Que→① When an object is charged mass of that object is decreased by 910×10^{-24} kg then find out charge on that object Also define type of charge.

Soln → Type of charge → +ve.

Because mass is decrease which means deficiency of e^-.

$\Delta M = 910 \times 10^{-24}$ kg

we know that = $\Delta M = n \times M_e$

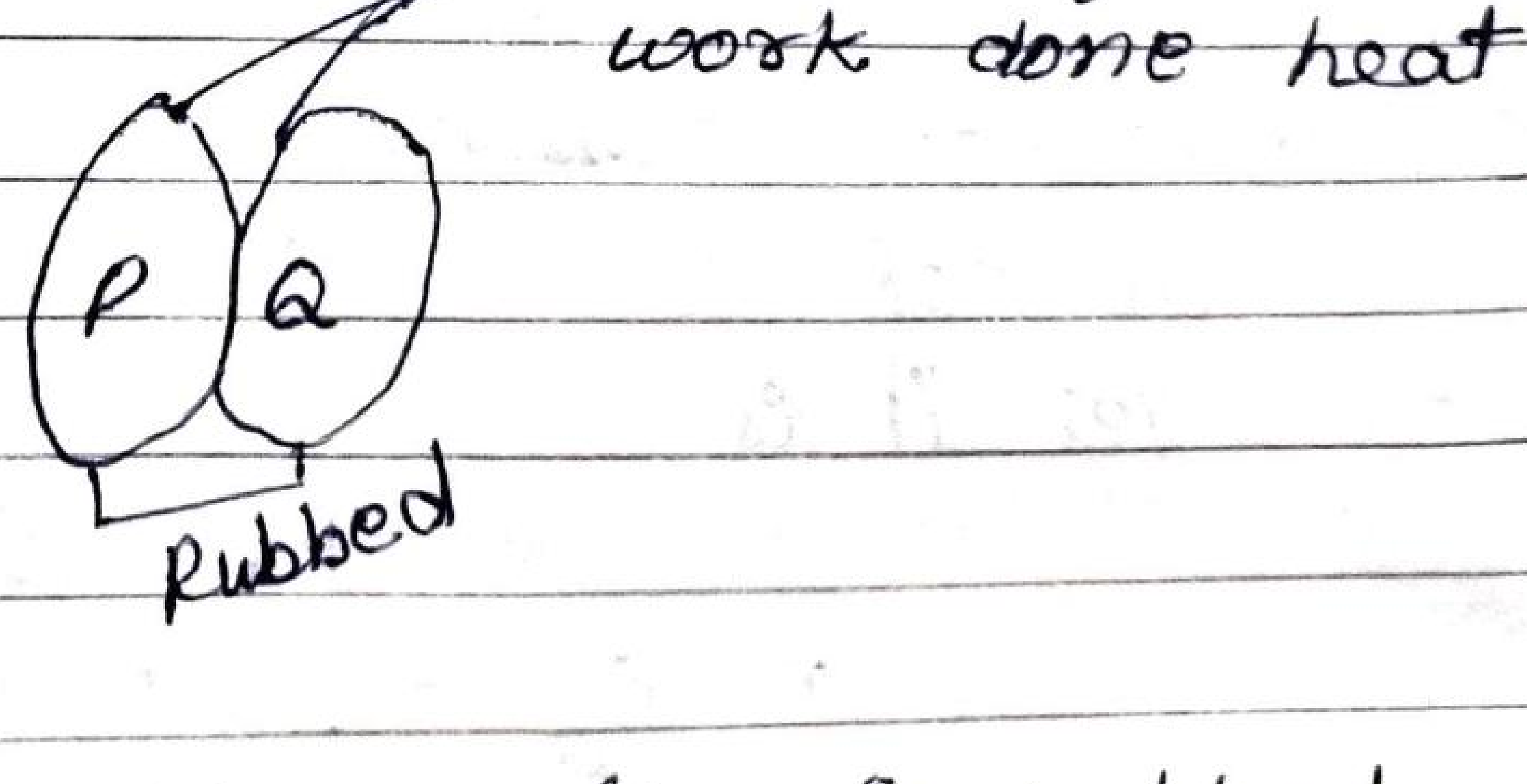
$n = \frac{910 \times 10^{-24}}{9.1 \times 10^{-31}} = 10^9$

$Q = ne = 10^9 \times 1.6 \times 10^{-19}$

$Q = 1.6 \times 10^{-11}$

☞ Type of charge.

Ⓐ By Friction



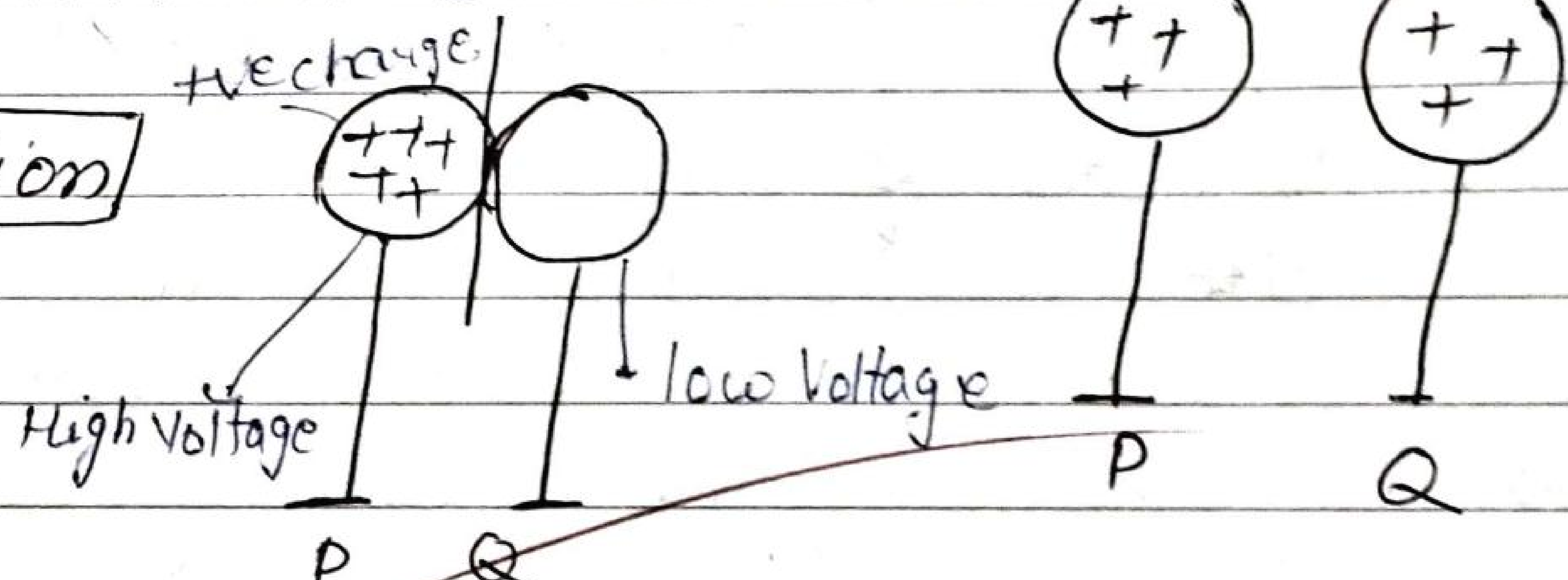
★ Two object P & Q as shown in fig. is rubbed with each other then friction b/w them will act due to this friction heat is generated.

* This heat is absorbed by free e^- of a metal due to this extra heat e^- of outer shell exited & emitted e^- in environment.
* These e^- are capture by another substance due to transfer of e^- object P will be e^- difficent while object Q will be efficent that is object P is +ve charge & object Q is -ve charge.

Note → when an e^- are transfer b/w object their will be less or gain in marks a/c to no. of e^- which is equal to $w = n \times me$

$$\Delta M = n me.$$

(B) By Conduction



* Two objects P and Q (P is +ve charge and Q is neutral) is placed near each other in such a way so they can touch each other.
  when these objects touch each other there will be an potential difference.
* Due to this potential difference charge will be resuffle And due to resuffle both objects P and Q will be chaged

Note → charge will resuffle in the ratio of radius of P and Q.

$$\frac{Q_1}{Q_2} = \frac{R_1}{R_2}$$

Scanned by TapScanner

Que→① If an object is positively charged with a charge of 256×10^{-17} C. then find out mass difference of that object.

Sol →

$Q = 256 \times 10^{-17}$ $\qquad \Delta m = ?$

$Q = ne$

$n = \frac{Q}{e} = \frac{256 \times 10^{-17}}{1.6 \times 10^{-19}} = 16 \times 10^{3}$

$\Delta m = 16 \times 10^{3} \times 9.1 \times 10^{-31}$ kg

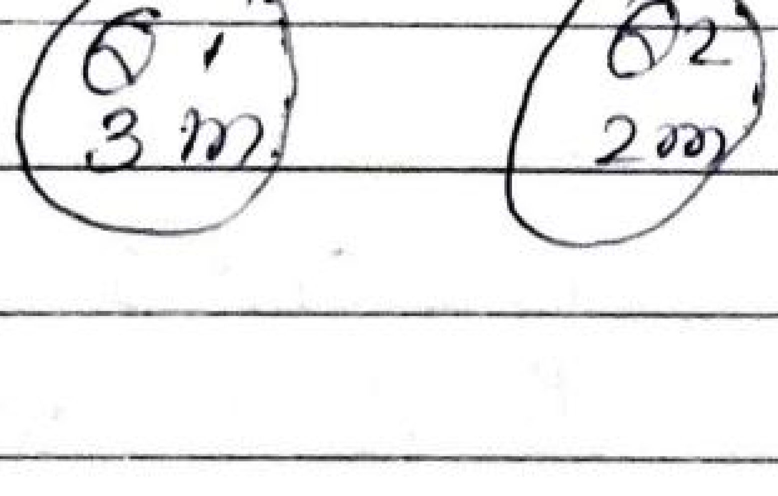
$\Delta m = 145.6 \times 10^{-28}$ kg.

Que→② If an object charged then massed of that object increased by 910×10^{-20} kg. then find out charge of that object in "esu"

$Q = 30.4 \times 10^{-18} \times 3 \times 10^{9}$ esu.

Que→③ An object of Radius - 3 m charged with a charge of 5 C If placed in contact with another object of radius of 2m then find the charge on every object.

Sol→



by charge Conservation →

charge before contact = charge after Contact

~~$5C + 0C = Q_1 + Q_2$~~

~~$5C = Q_1 + Q_2$~~ — ①

By the theory of charging by conduction →

$\frac{Q_1}{Q_2} = \frac{R_1}{R_2}$

$Q_1 = \frac{3}{2} Q_2$ — ②

By putting value of Q_1 in eq - ①

$5 = Q_1 + Q_2$

$5 = Q_1 + 2$

$Q_1 = 3.$

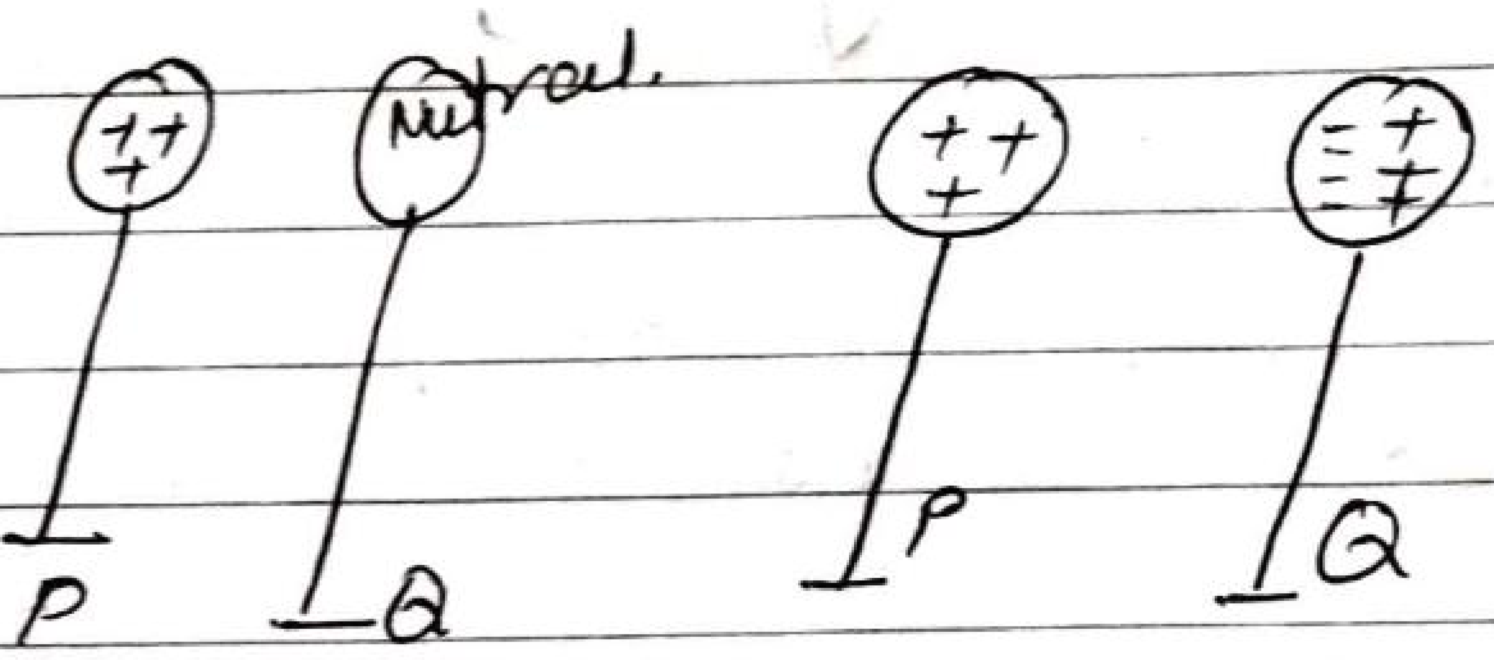
* Work function → Energy required to emit a e^- from outer orbit of an atom is known as work function.

- It is represented by "Q"
- Unit → Joule.

Note → ① Heigher work function means stronger attraction force and lower work function means week attraction

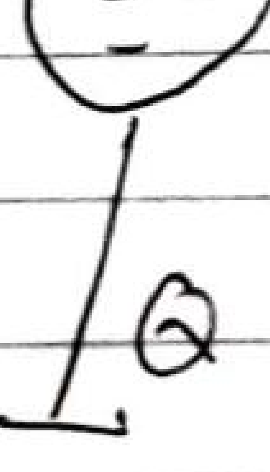
② Strong force laid to emit e^- at very High effort while weaker force laid to emit e^- at a low effort.

ⓒ By Induction



- Object P and Q (P +ve charge Q is Neutral) place near each other
- due to object P charge of Q partialy Sapvated.

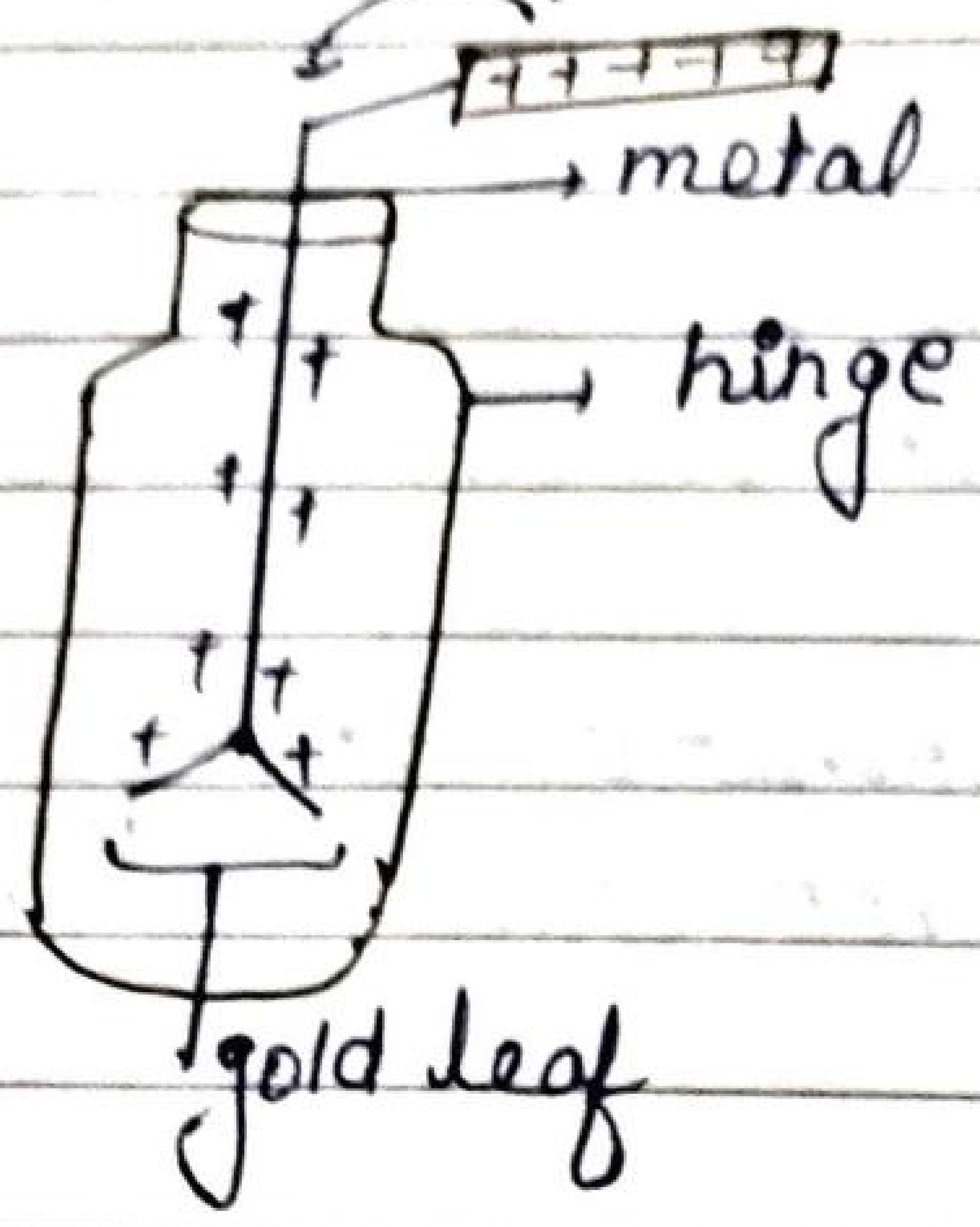
* The second side of object Q is conected with earth (i.e – earthing) due to earthing 2nd side of Q will be neutral.



-ve charge on object will be equally distributed.

Electroscope.

It is an instrument which is used to measure the charge of a charged body.



* Construction

→ electroscope is made up by using gold leaves, metalic Rod and a glass container.

→ metalic rod is connected with gold leave in such way that gold leaves can be seporated out while both are charged.

→ This combination of metalic rod and gold leave is placed in glass container with the help of insulator cork.

* Working.

→ when charged body connected to metalic rod charge of that body will be transfered to the metallic Rod and this charge is further transfer to the gold leaves.

→ When charges transfer to the gold leaves both leaves are charged by same type of charge due to like charge gold leave will repel each other due to this repulsive force gold leaves are seperated out which defiene charge of a body.

☞ Coulamb's law

→ A/c to thelus, there will be attractive or repulsive force b/w two charge but thelus doesn't define the quantity of attractive or repulsive force.

→ Coulamb's a french scientist defines the quantity of force and gives a law which is known as Coulamb's law.

★ Coulamb's Statement → A/c to coulamb, quantity of force will be ~~F~~ proportional to multiple of charges

$$f \propto q_1 q_2 \quad \text{—} ①$$

A/c to Coulomb force inversly proportional to the Square of distance b/w charges

$$f \propto \frac{1}{r^2} \quad \text{—} ②$$

then, from eq① and eq②

$$f \propto \frac{q_1 q_2}{r^2}$$

$$f = \frac{K q_1 q_2}{r^2}$$

K = Porpotinality Constant

+ve = Repulsive

−ve = Attractive.

Unit = $K = \frac{f r^2}{q_1 q_2} = \frac{N\text{-}m^2}{C^2}$

Dimension = $K = \frac{[M^1 L^1 T^{-2}][L^2]}{[A^2 T^2]}$

$K = [M^1 L^3 T^{-4} A^{-2}]$

Que → ① Two charge of 2 μc and 7 μc is placed at a distance of 3 cm. find the type and quantity of force.

→ $f = \frac{K q_1 q_2}{r^2} = \frac{9\times10^9 \times 2\times10^{-6} \times 7\times10^{-6}}{3\times3\times10^{-2}\times10^{-2}}$

$= 14\times10^{13}\times10^{-12}$

$f = 140N.$

Que → ② Two unlike charges of same magnitude placed at a distance of 4cm and feel an force of 1440N. find the change in mass of that charges.

→ $f = \frac{K q_1 q_2}{r^2}$

$1440 = \frac{9\times10^9\, q_1 \cdot q_2}{(4\times10^{-2})^2} \quad (q_1 = q_2)$

$q^2 = \frac{1440 \times 16\times10^{-4}}{9\times10^9}$

$q = \sqrt{\frac{144 \times 16\times10^{-12}}{9}}$

$q = \frac{12\times4}{3}\times10^{-6}$

$q = 16\, \mu C$

Quantisation of charge →

$n = \frac{q}{e} = \frac{16\times10^{-6}}{1.6\times10^{-19}}$

$n = \frac{q}{e} = \frac{16\times10^{-6}}{16\times10^{-20}} = 10^{14}$

$\Delta m = n \times m_e$

$\Delta m = 10^{14}\times 9.1\times10^{-31}$

$\Delta m = 9.1\times10^{-17}\, Kg.$

PAGE NO.
DATE:

* K = Porporsnality constant

$$f = \frac{K q_1 q_2}{r^2}$$

* $K = \frac{1}{4\pi \varepsilon_0}$ $\varepsilon_0 = 8.85 \times 10^{-12}$
electronic permitivity of Vaccume.

Unit of ε_0 →

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

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

$$\varepsilon_0 = \frac{q_1 q_2}{4\pi f r^2} = \frac{C^2}{N\text{-}m^2} \left[K \propto \frac{1}{\varepsilon_0} \right]$$

Dimensiof ε_0 →

$$\varepsilon_0 = \frac{[A^1 T^1]^2}{[M^1 L^1 T^{-2}][L^2]} = \frac{A^2 T^2}{M^1 L^3 T^{-2}}$$

$$\varepsilon_0 = [M^{-1} L^{-3} T^4 A^2]$$

* Force between two charges in a given medium.

f_0 = force in vaccume
f_m = force in medium

$$f_0 = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{r^2}$$

$$f_m = \frac{1}{4\pi\varepsilon_m} \times \frac{q_1 q_2}{r^2}$$

ε_m = electronic permitivity in medium

Note → ε_m is an theoritical concept
ε_r is used at the place of ε_m

* Relative Permittivity

$$\varepsilon_r = \frac{f_o}{f_m} = \frac{\text{force in vaccume}}{\text{force in medium}}$$

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

$$\varepsilon_r = \frac{\frac{1}{\varepsilon_0}}{\frac{1}{\varepsilon_m}} = \frac{\varepsilon_m}{\varepsilon_0}$$

Que→ ① Write the dimension & unit of ε_r.

→ ε_r is unit and dimension less quantity.

(ε_r)	(medium)
1.056	air = vaccume
2 – 5	glass
80	water
42.7	glycerin
∞	metals

* Relation b/w f_o and f_m

$$f_m = \frac{1}{4\pi\varepsilon_m} \times \frac{q_1 q_2}{r^2}$$

$\varepsilon_r = \frac{\varepsilon_m}{\varepsilon_0}$ (By the deffination of ε_r)

$$\varepsilon_m = \varepsilon_r \cdot \varepsilon_0$$

$$f_m = \frac{1}{4\pi\varepsilon_0} \cdot \frac{1}{\varepsilon_r} \cdot \frac{q_1 q_2}{r^2}$$

$$f_m = \frac{1}{\varepsilon_r}\left[\frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{r^2}\right]$$

$$\boxed{f_m = \frac{1}{\varepsilon_r} \times f_0}$$

Que→① Two charges of $3\mu C$ and $6\mu C$ are placed in a water Container at a distance of 20 cm. find out the force between them.

→

$$\varepsilon_m = \varepsilon_r \cdot \varepsilon_0$$

$$f_m = \frac{1}{4\pi\varepsilon_0} \cdot \frac{1}{\varepsilon_r} \cdot \frac{q_1 q_2}{r^2}$$

$$f_m = \frac{K q_1 q_2}{r^2 \varepsilon_r} = \frac{9\times10^9 \times 3\times10^{-6} \times 6\times10^{-6}}{80 \times (20\times10^{-2})^2}$$

$$f_m = \frac{9\times10^9 \times 3\times6\times10^{-12}}{80\times 400\times10^{-4}}$$

$$f_m = \frac{9\times18\times10^{-3}}{8\times4\times10^{-1}} = \frac{9\times18\times10^{-2}}{8\times4}$$

$$f_m = \frac{81}{16}\times10^{-2}\,N.$$

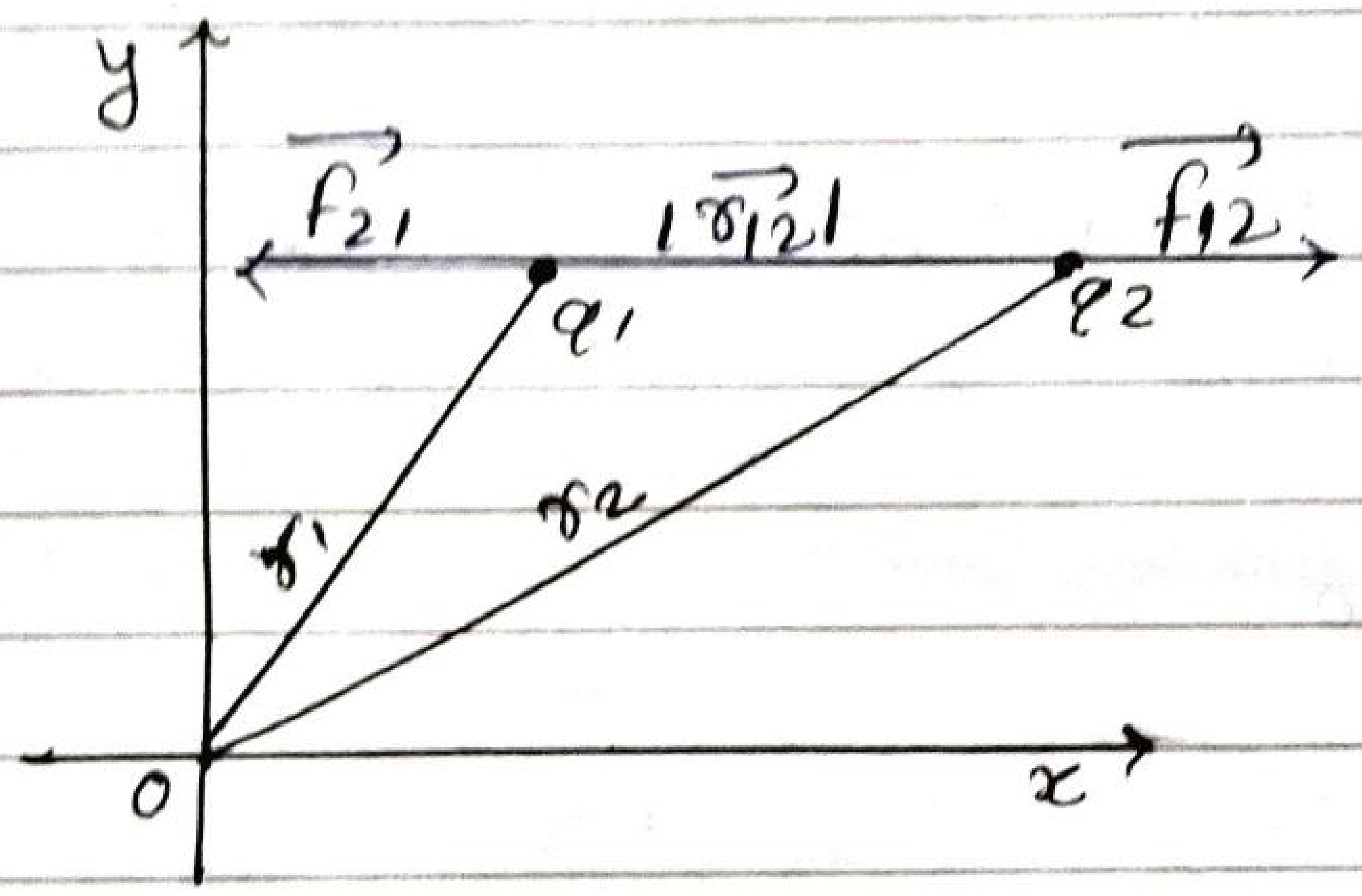
Que→② Two charges are placed at a distance in vaccume and attract each other by 22N. if a plate of Pottasium is palaced b/w them. then what will be the force between them.

$$\rightarrow \quad F_m = \frac{1}{\varepsilon_r} \times F_0$$

$$F_m = \frac{1}{\infty} \times 22$$

$$F_m = \frac{22}{\infty} = 0$$

* Vector forms of Coulamb's law.



→ As shown in fig. two charges q_1 & q_2 are placed in cartesion system with the position $\vec{r_1}$ & $\vec{r_2}$.

→ we have to find out the force oppositing by both charge on each other.

Hence by Coulamb law :-

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

$$\vec{r_{21}} = \vec{r_2} - \vec{r_1}$$

$$|\vec{r_{21}}|^2 = r$$

Multiplying by unit vector

$$\vec{F} = \frac{K q_1 q_2}{|\vec{r}_{21}|^2} (\hat{r}_{21})$$

$$\hat{r}_{21} = \frac{\vec{r}_{21}}{|\vec{r}_{21}|}$$

$$\vec{F}_{21} = \frac{K q_1 q_2}{|r_{21}|^2} \cdot \frac{\vec{r}_{21}}{|r_{21}|}$$

$$\vec{f}_{21} = \frac{K q_1 q_2}{|\vec{r}_{21}|^3} (\vec{r}_{21})$$

$$\vec{F}_{21} = \frac{K q_1 q_2}{|\vec{r}_2 - \vec{r}_1|^3} (\vec{r}_2 - \vec{r}_1)$$

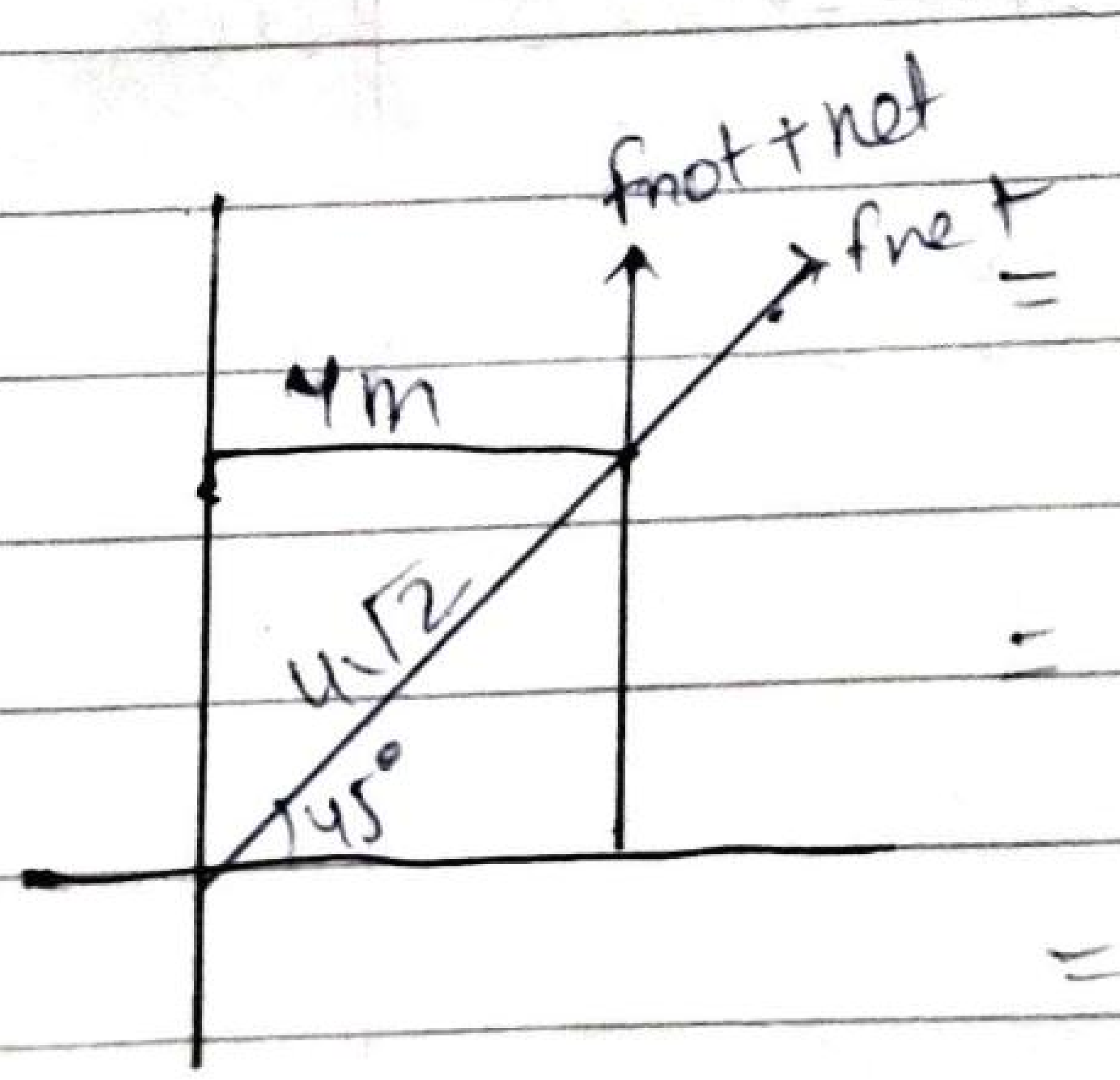
$$\vec{f}_{21} = -\vec{f}_{21}$$

Que→① Two charge of 6C or 4C are placed on diagonal of a square of side 4m. then find out force applied on 4C charge.

→

$$f = \frac{K q_1 q_2}{r^2}$$

$$= \frac{9\times10^9 \times 6\times1.6\times10^{-19} \times 4\times1.6\times10^{-19}}{(4\sqrt{2})^2}$$



$$= \frac{9\times10^9 \times 6\times1.6\times10^{-19} \times 4\times1.6\times10^{-19}}{32}$$

$$= \frac{9\times10^9 \times 6 \times 1.6 \times 1.6\times10^{-38}}{8}$$

$$= 9\times3\times0.6\times1.6\times10^{-29}\ N$$

Que → ② Two charges 5C and 3C are placed at A & B then find out force applied by 5C on 3C then, if co-ordinates of A and B in (2,3) and (-5,4)

→ Vector form of Coulamb's law -

$$\vec{F} = \frac{K q_1 q_2}{|\vec{r_{12}}|^3} (\vec{r_{12}})$$

$q_1 = 5C$

$q_2 = 3C$

$K = 9 \times 10^9 \ Nm^2/c^2$

$\vec{r_{12}} = \vec{r_1} - \vec{r_2}$

$\vec{r_1} = -5\hat{i} + 4\hat{j}$

$\vec{r_2} = 2\hat{i} + 3\hat{j}$

$\vec{r_{12}} = (-5\hat{i} + 4\hat{j}) - (2\hat{i} + 3\hat{j})$

$\vec{r_{12}} = -7\hat{i} + \hat{j}$

$|\vec{r_{12}}| = \sqrt{x^2 + y^2 + z^2}$

$|\vec{r_{12}}| = \sqrt{50}$

$$\vec{F} = \frac{9 \times 10^9 \times 5 \times 3}{(\sqrt{50})^3} \times (-7\hat{i} + \hat{j})$$

Que → ③ Two charge 4C and 7C are placed at A and B. find out force applied by 7C on 4C charge. if co-ordinates of A and B is (1,2) or (4,6) respactively.

→ $$\vec{F} = \frac{K q_1 q_2}{|\vec{r_{12}}|^3} (\vec{r_{12}})$$

$\vec{r_{12}} = \vec{r_1} - \vec{r_2}$

$\vec{r_1} = 1\hat{i} + 2\hat{j}$

$\vec{r_2} = 4\hat{i} + 6\hat{j}$

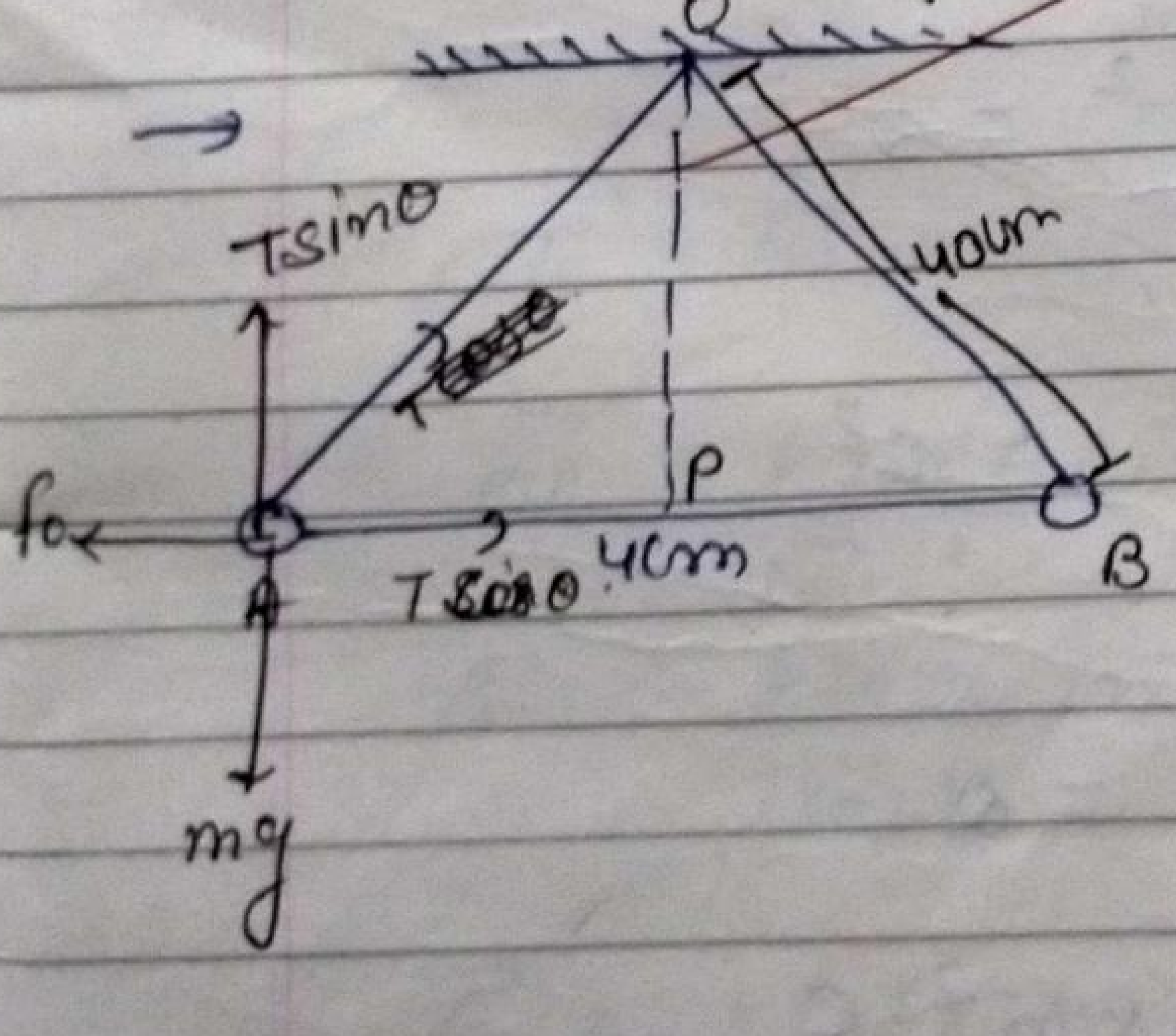
$\vec{r_{12}} = (\hat{i} + 2\hat{j}) - (4\hat{i} + 6\hat{j})$

$\vec{r_{12}} = -3\hat{i} - 4\hat{j}$

$|\vec{r_{12}}| = \sqrt{(-3)^2 + (-4)^2} = \sqrt{25} = 5$

$$f = \frac{9\times10^9 \times 7\times4}{(5)^3} \times (-3\hat{i} - 4\hat{j})$$

Que→③ Two identical metallic sphere of mass 200 gm tied up by a string of 40 cm length. Both sphere are charged by same charge. If in quilibrium condition both sphere are at a distance of 4cm. then find out charged of that sphere.



$\tan\theta = \frac{P}{B}$

$\tan\theta = \frac{OP}{PA}$

$\tan\theta = \frac{40}{2} = 20$

$\sin\theta = 20$

$\cos\theta = 1$

By applying condition of equili→

$f_{net} = 0$

$f_x = 0$

$T\cos\theta - f_e = 0$

$T\cos\theta = f_e$ — ①

$T\sin\theta - mg = 0$

$T\sin\theta = mg$ — ②

$\sin 20 \rightarrow$

$T \times 20 = mg$

$T \times 20 = 2$

$T = 0.1 N$

$\cos\theta = 1 \rightarrow \quad T \times 1 = f_e$

$$0.1 N = \frac{KQQ}{r^2}$$

$$\frac{0.1 \times r^2}{K} = Q^2$$

$$\frac{0.1 \times (4 \times 10^{-2})^2}{9 \times 10^9} = Q^2$$

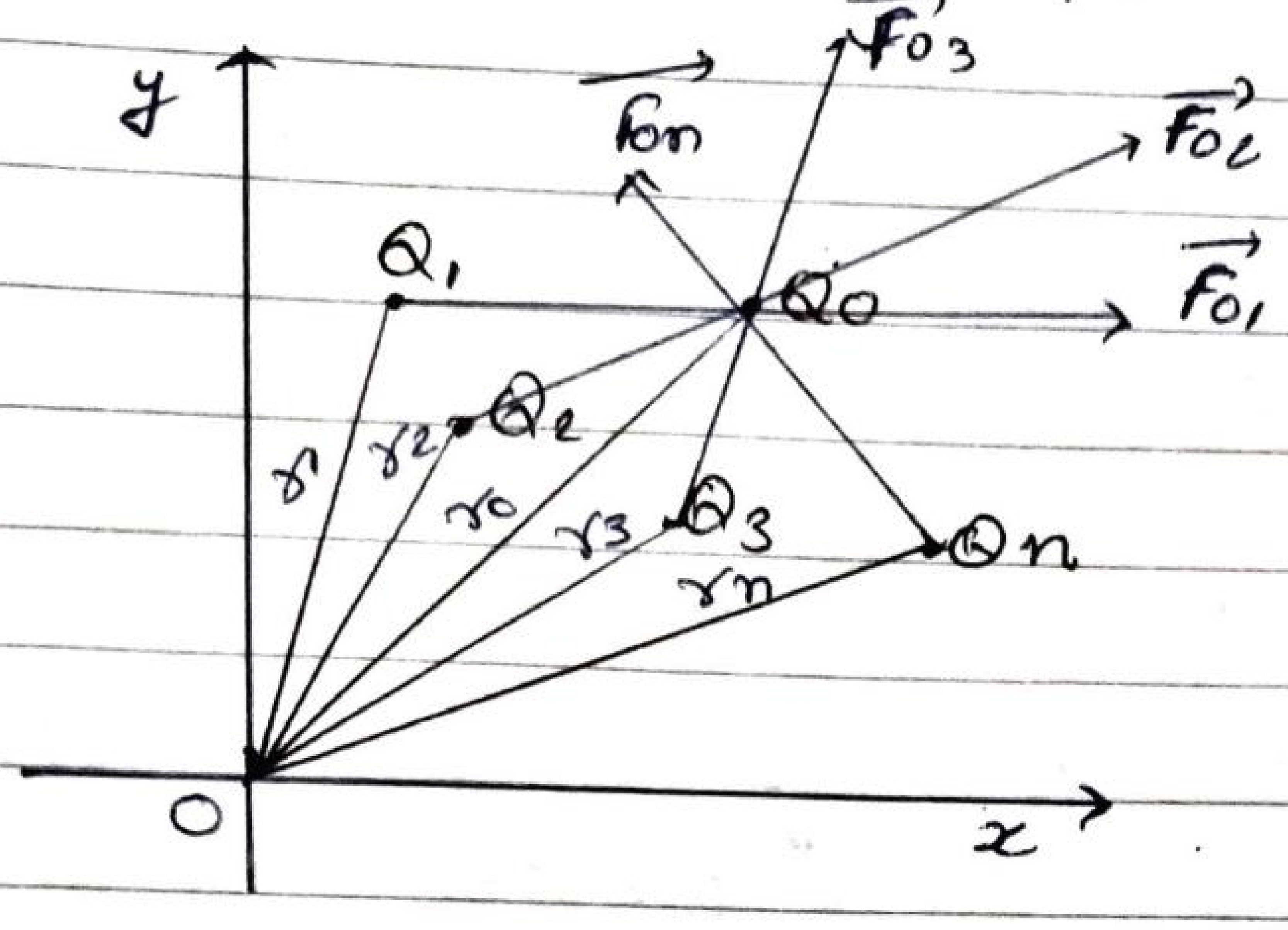
$$\frac{1 \times 10^{-1} \times 16 \times 10^{-14}}{9 \times 10^9} = Q^2$$

$$\sqrt{\frac{16}{9} \times 10^{-14}} = Q$$

$$Q = \frac{4}{3} \times 10^{-7} C$$

$$Q = 1.33 \times 10^{-7} C.$$

* Super ~~im~~position Principal



- Super position principal is used when many charges attract or repel a single charge.

★ A/c to super position principal net force applied on charge is equal to sum of force applied by individual charges.

~~$$\vec{F_{12}} = \frac{k q_1 q_2}{|\vec{r_{12}}|^3} (\vec{r_{12}})$$~~

$$\vec{F_o} = \vec{F_{o1}} + \vec{F_{o2}} + \vec{F_{o3}} \; --- \; \vec{F_{on}}$$

$$\vec{F_{o1}} = \frac{k q_o q_1}{|\vec{r_{o1}}|^3} (\vec{r_{o1}}) \qquad \vec{F_{on}} = \frac{k q_o q_n}{|\vec{r_{on}}|^3} (\vec{r_{on}})$$

$$\vec{F_{o2}} = \frac{k q_o q_2}{|\vec{r_{o2}}|} (\vec{r_{o2}})$$

$$\vec{F_o} = \frac{k q_o q_1}{|\vec{r_{o1}}|} (\vec{r_{o1}}) + \frac{k q_o q_2}{|\vec{r_{o2}}|} (\vec{r_{o2}}) \; --- \; \frac{k q_o q_n}{|\vec{r_{on}}|} (\vec{r_{on}})$$

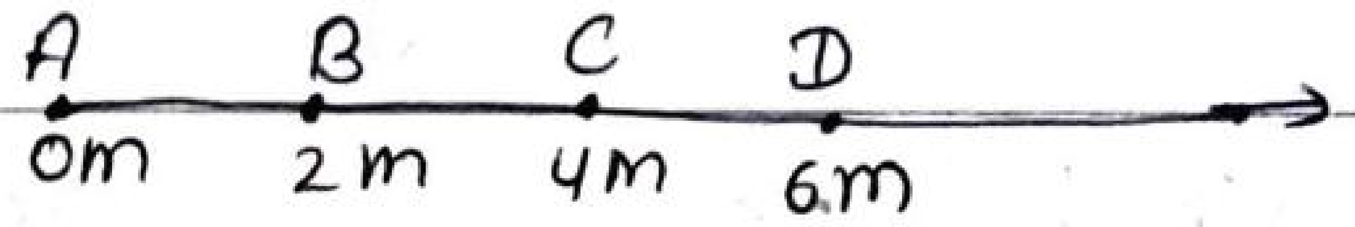
Scanned by TapScanner

$$\vec{F_0} = Kq_0\left[\frac{q_1}{|\vec{r_{01}}|^3}(\vec{r_{01}}) + \frac{q_2}{|\vec{r_{02}}|^3}(\vec{r_{02}}) + \cdots \frac{q_n}{|\vec{r_{0n}}|}(\vec{r_{0n}})\right]$$

$$\vec{F_0} = Kq_0 \sum_{i=1}^{n} \frac{q_i}{|\vec{r_{0i}}|^3}(\vec{r_{0i}})$$

Que→① For equal charges each of charge 2C are located on x- axis. they are situated on 0m, 2m, 4m and 6m then find out the net ~~charge~~ /force on charge situated at 2m.

Soln →



$$\vec{F_B} = \vec{F_{BA}} + \vec{F_{BC}} + \vec{F_{BD}}$$

$$\vec{F_{BC}} = \frac{K \times 2 \times 2}{(4-2)^3}(2\hat{i} - 4\hat{i})$$

$$\vec{F_{BA}} = \frac{K \times 2 \times 2}{(2-0)^3}(2\hat{i} - 0\hat{i})$$

$$\vec{F_{BD}} = \frac{K \times 2 \times 2}{(6-2)^3}(2\hat{i} - 6\hat{i})$$

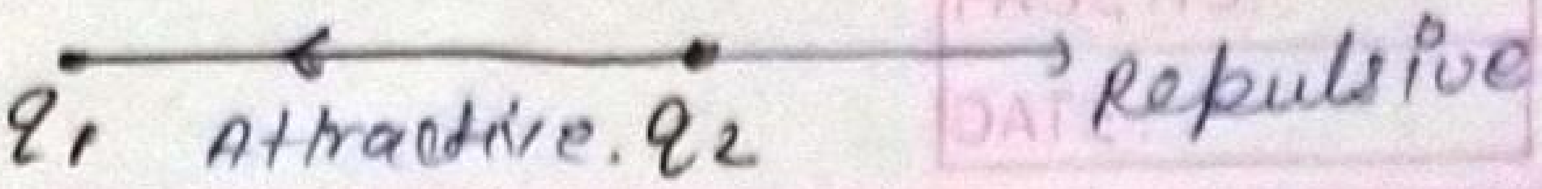
$$\vec{F_B} = \frac{-K \times 2 \times 2}{2 \times 2 \times 2} \times 2\hat{i} + \frac{K \times 2 \times 2}{2 \times 2 \times 2} 2\hat{i} + \frac{K \times 2 \times 2}{4 \times 4 \times 4} \times (-4\hat{i})$$

$$\vec{F_B} = -K\hat{i} + K\hat{i} - \frac{K\hat{i}}{4}$$

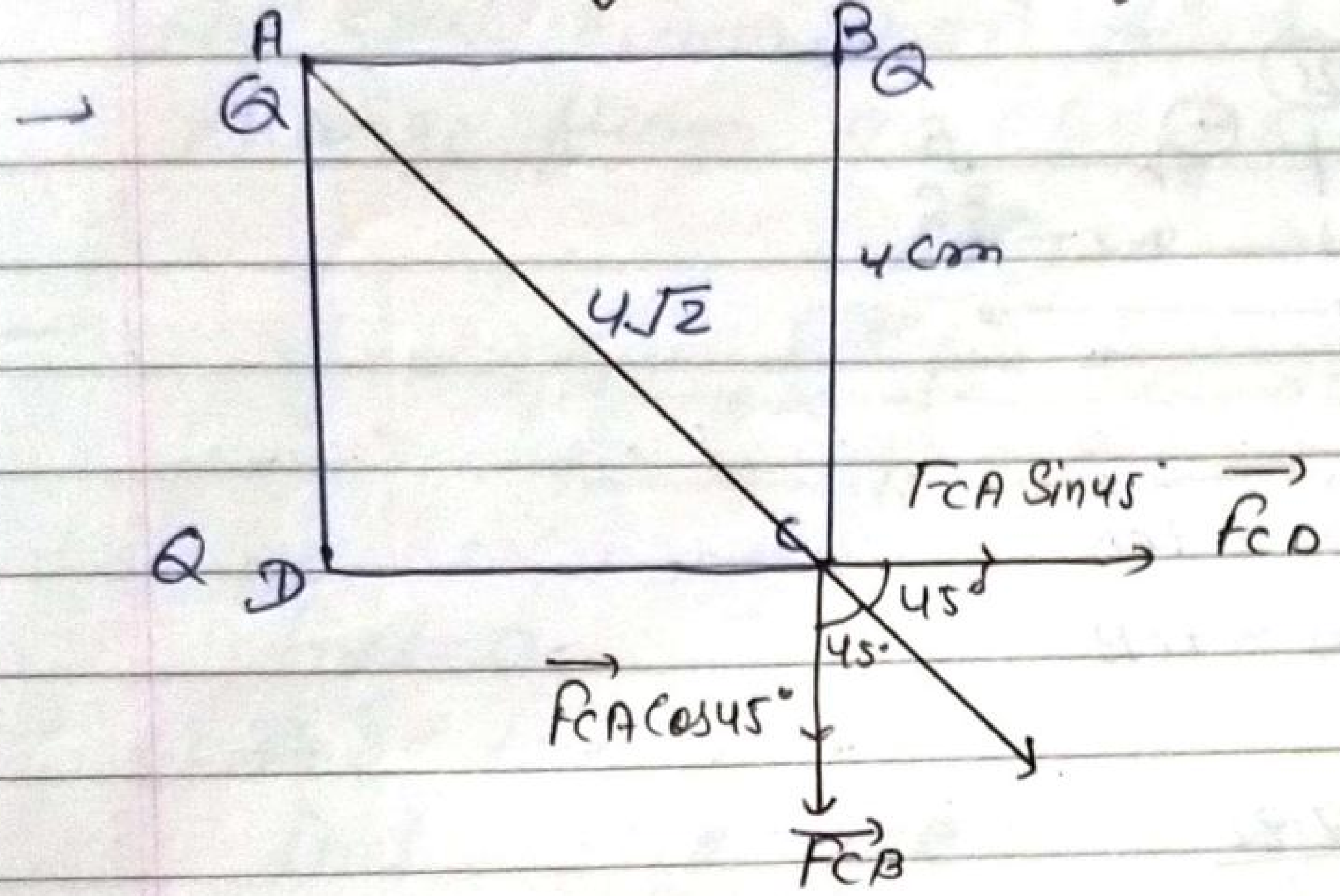
$$\vec{F_B} = \frac{-K}{4}\hat{i}$$

$$\vec{F_B} = \frac{9 \times 10^9}{4}\hat{i} = -2.25 \times 10^9 \hat{i}$$

Note → Direction of force b/w 2 charges is parallel to line joining the charges



Que→② Four charge of 4c are placed at Corners of a square ABCD of side 4cm. Then find net force applied on 'c' by other charge.



$\vec{F_{CD}} = \frac{K q_1 q_2}{r^2}$

$= \frac{9\times10^9 \times 16}{(4\times10^{-2})^2}$

$\vec{F_{CD}} = \frac{9\times10^9\times16}{16\times10^{-4}}$

$\vec{F_{CD}} = 9\times10^{3}N$

$\vec{F_{CB}} = 9\times10^{3}N$

$\vec{F_{CA}} = \frac{9\times10^9\times16}{(4\sqrt{2}\times10^{-2})^2}$

$\vec{F_{CA}} = 4.5\times10^{13}N.$

$F_{net}(x) = F_{CD} + F_{CA}\sin45°$

$= 9\times10^{13} + 4.5\times10^{13}\times\frac{1}{\sqrt{2}}$ (P)

$F_{net}(y) = F_{CB} + F_{A}\cos45°$

$= 9\times10^{13} + 4.5\times10^{3}\times\frac{1}{\sqrt{2}}$ (P)

$F_{net} = \sqrt{F_x^2 + F_y^2}$

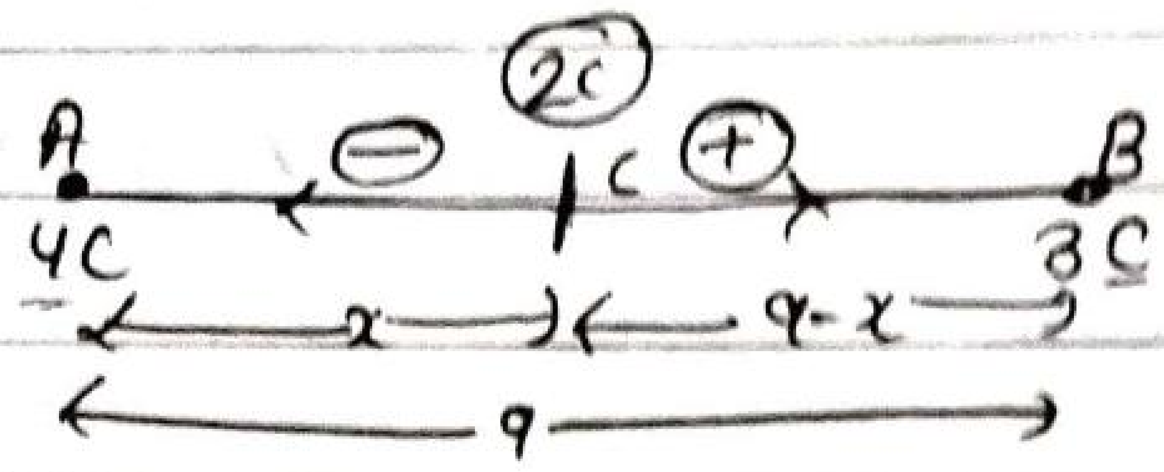
$F_{net} = \sqrt{P^2+P^2} = P\sqrt{2}$

$F_{net} = \left(9\times10^{13} + \frac{4.5\times10^{3}}{\sqrt{2}}\right)\sqrt{2}$

$F_{net} = \left[4.5\times10^{13}\left(2+\frac{1}{\sqrt{2}}\right)\sqrt{2}\right]$ Along the diagonal of AC.

Que → ③ Two charges of 4C and 3C are placed at a distance of 9cm. where should charge of 2C placed so 2C charge feel zero force.

→



$F_{net} = 0$

$\vec{F_C} = \vec{F_{CA}} + \vec{F_{CB}}$

$F_{net} = F_{CA} - F_{CB}$

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

$F_{CA} = \frac{k \times 4 \times 2}{x^2}$, $F_{CB} = \frac{k \times 3 \times 2}{(9-x)^2}$

$F_{net} = \frac{k \times 4 \times 2}{x^2} - \frac{k \times 3 \times 2}{(9-x)^2}$

$\frac{k \times 4 \times 2}{x^2} = \frac{k \times 3 \times 2}{(9-x)^2}$

$\frac{4}{3} = \frac{x^2}{(9-x)^2}$

$\sqrt{\frac{4}{3}} = \frac{x}{9-x}$

$\frac{2}{\sqrt{3}} = \frac{x}{9-x}$

$18 - 2x = \sqrt{3}x$

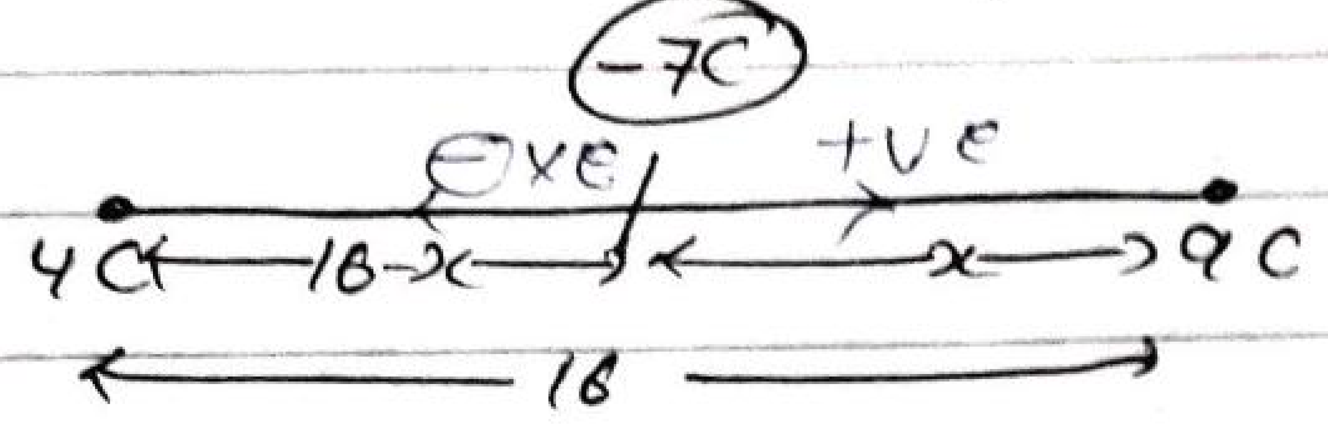
$18 = (\sqrt{3}+2)x$

$x = \frac{18}{(1.732+2)}$

$x = \frac{18}{3.732}$

Que-(4) 2 charges of 4C and 9C are placed at a distance of 16 cm. At a distance of 16 cm. A charge -7C is placed b/w these charges and this charge is in equilibrium then find out distance of -7C charge from 9C charge

→



$f_{net} = 0$

$\vec{f_C} = \vec{f_{CA}} + \vec{f_{CB}}$

$f_{net} = f_{CB} - f_{CA}$

$f_{CA} = \frac{K(-7)(4)}{(16-x)^2}$, $f_{CB} = \frac{K(-7)(9)}{x^2}$

$f_{net} = -\frac{K(-7)(4)}{(16-x)^2} + \frac{K(-7)(9)}{x^2}$

$\frac{K(-7)(4)}{(16-x)^2} = \frac{K(-7)(9)}{x^2}$

$\sqrt{\frac{4}{9}} = \frac{16-x}{x}$

$\frac{2}{3} = \frac{16-x}{x}$

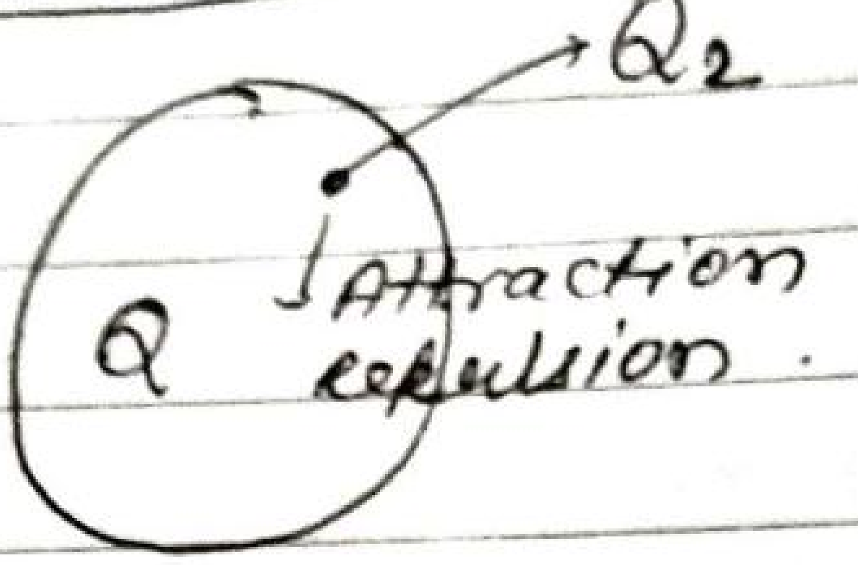
$2x = 48 - 3x$

$5x = 48$

$x = \frac{48}{5} = 9.6$

Electric field.

→



→ An electric charge consist a circular field around the charge in which if any charged is placed then the another charge feel attractive or Repulsive force.
This circular field is known as electric field.

→ We can say that effective area of charge is known as electric field.

Electric field intencity

→ Force applied on a unit charge is known as EFI.

→ EFI represented by 'E'

→ Its an vector quantity.

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

Unit = N/C

Dimension = $M^1 L^1 T^{-3} A^{-1}$

* Electric field intensity due to a point charge

Note → In numericals generally SI system is used.

By Coulomb's law →

$$f = \frac{KQq}{r^2} \qquad Q_1 = Q,\; Q_2 = q,\; r = r$$

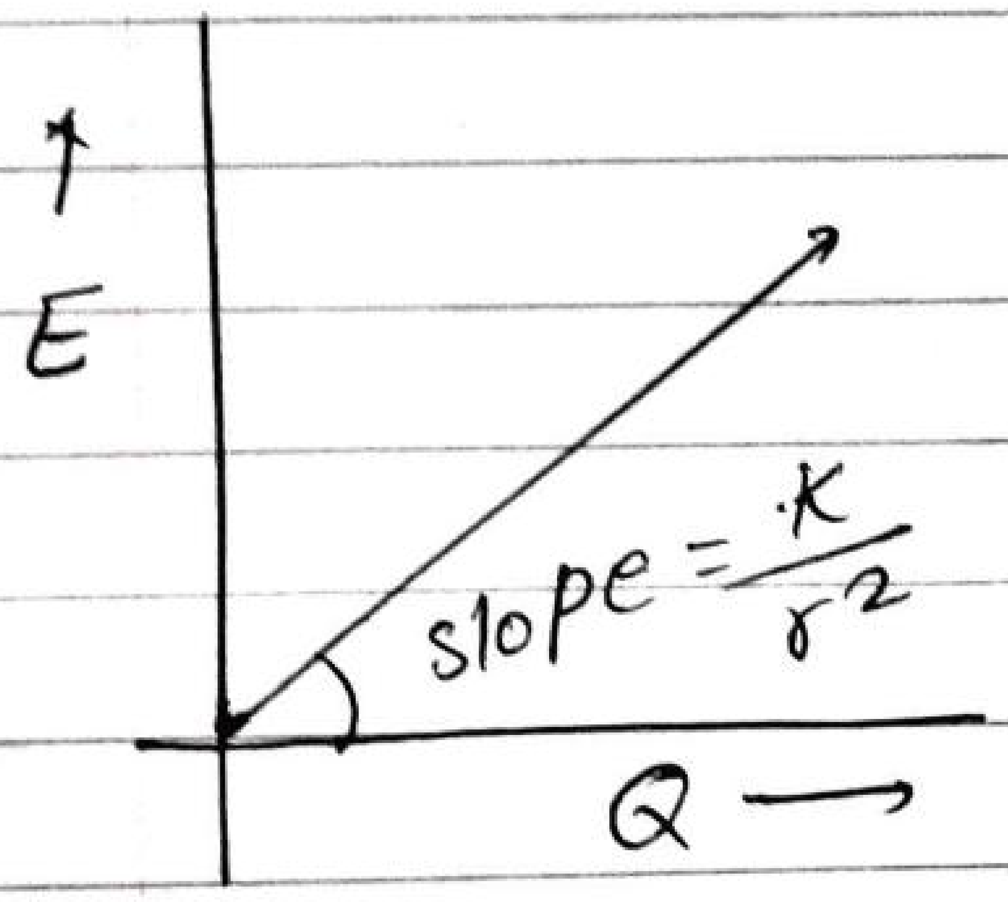
EFI →

$$\vec{E} = \frac{\vec{f}}{\vec{q}} \quad \text{--- (1)}$$

$$E = \frac{f}{q}$$

By eq^n first →

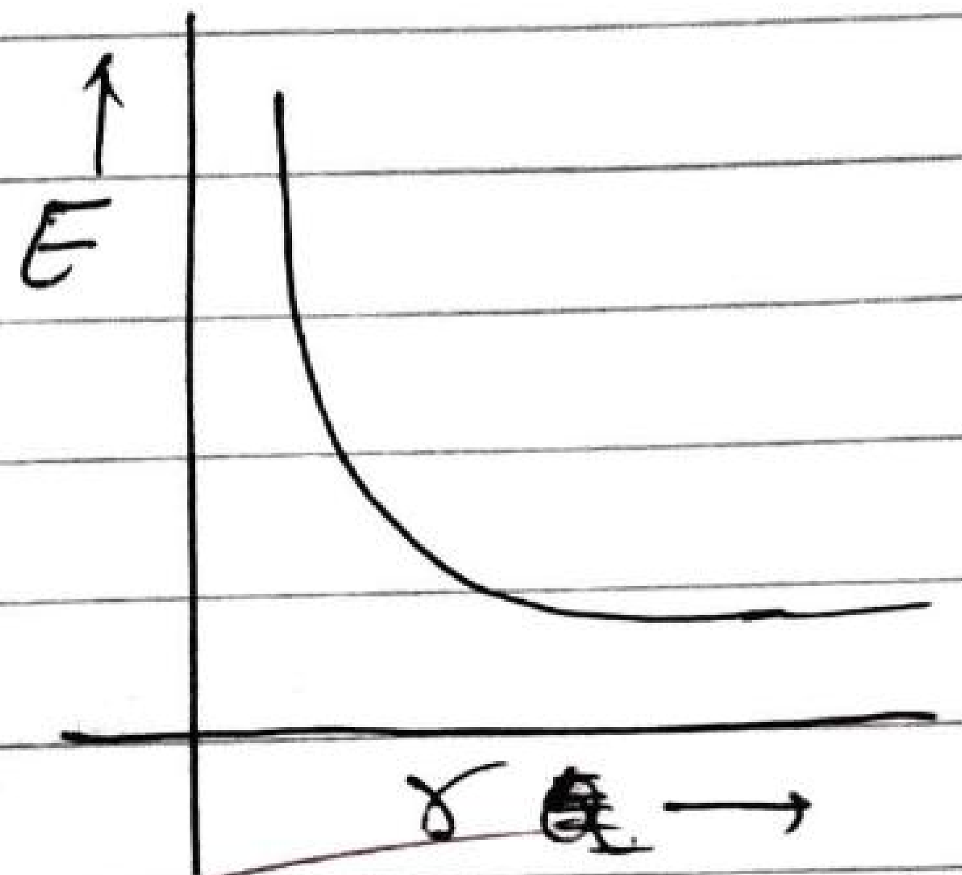
$$E = \frac{\frac{KQq}{r^2}}{q}$$



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

$E \propto Q$

$E \propto \frac{1}{r^2}$



Que → (1) Find out EFI due to a point charge of 3C at a distance of √3 cm from a point charge.

→

$$E = \frac{f}{q}$$

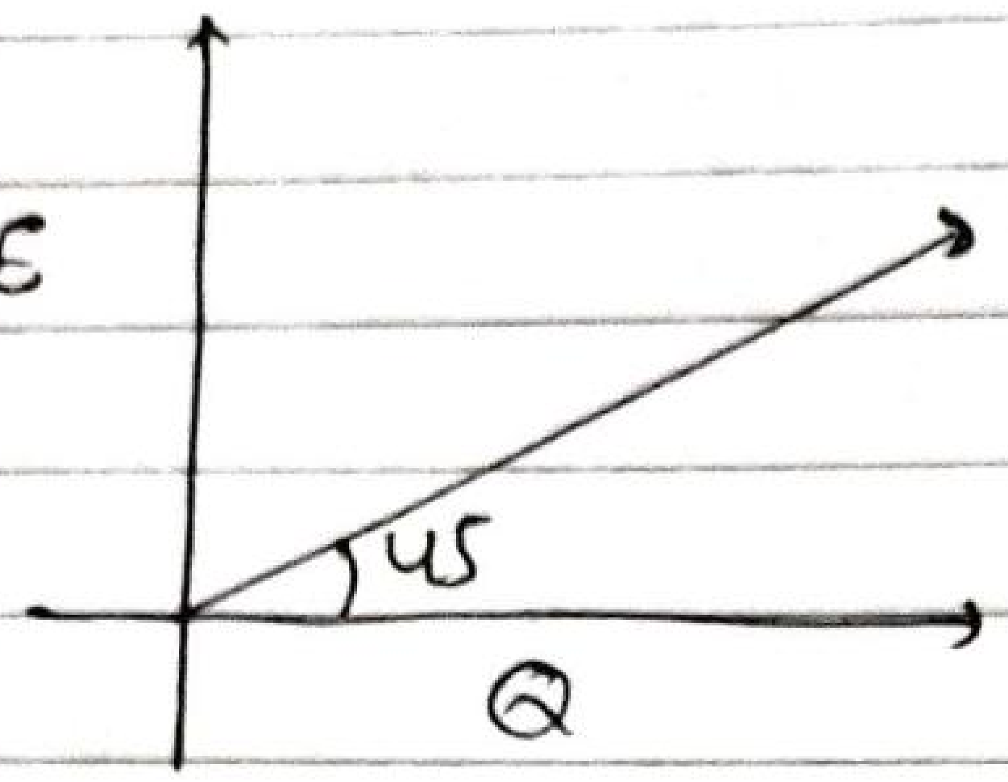
$$E = \frac{\frac{K \times Q \cdot q}{r^2}}{q}$$

$$E = \frac{9 \times 10^9 \times 3}{(\sqrt{3} \times 10^{-2})^2}$$

$$E = \frac{9 \times 10^9 \times 3}{3 \times 10^{-4}}$$

$$E = 9 \times 10^{13} \text{ N/C}$$

Que→② In given curve of E-Q find the value of r.



→ $\text{slope} = \tan\theta = \frac{K}{r^2}$

$$\tan 45 = \frac{9\times10^9}{r^2}$$

$$r = \sqrt{9\times10^9}$$

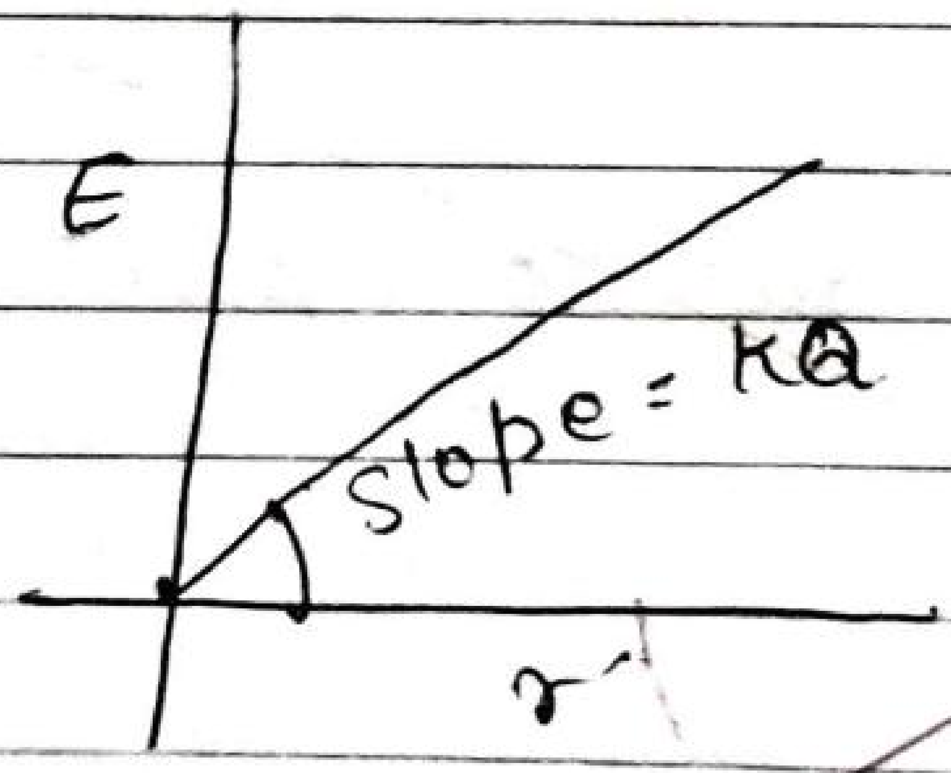
$$r = 3\times10^{9/2}\ m$$

Que→③ Draw a graph b/w $E - \frac{1}{r^2}$

→ $E = KQ\frac{1}{r^2}$

$y = KQ\,x$

$y = mx$



Note → $\because E = \frac{F}{q}$

or $F = \frac{Kq_1q_2}{r^2}$

$F = \frac{q_1q_2}{4\pi\varepsilon_0 r^2}$

If charged is placed in a medium then force will decrease hence, EFI will also decrease.

$$E_0 = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

E_0 = EFI in Vaccume.

$$E_m = \frac{1}{4\pi\varepsilon_m}\cdot\frac{q}{r^2}$$

$\varepsilon_r = \frac{\varepsilon_m}{\varepsilon_0}$ (relative permitivity)

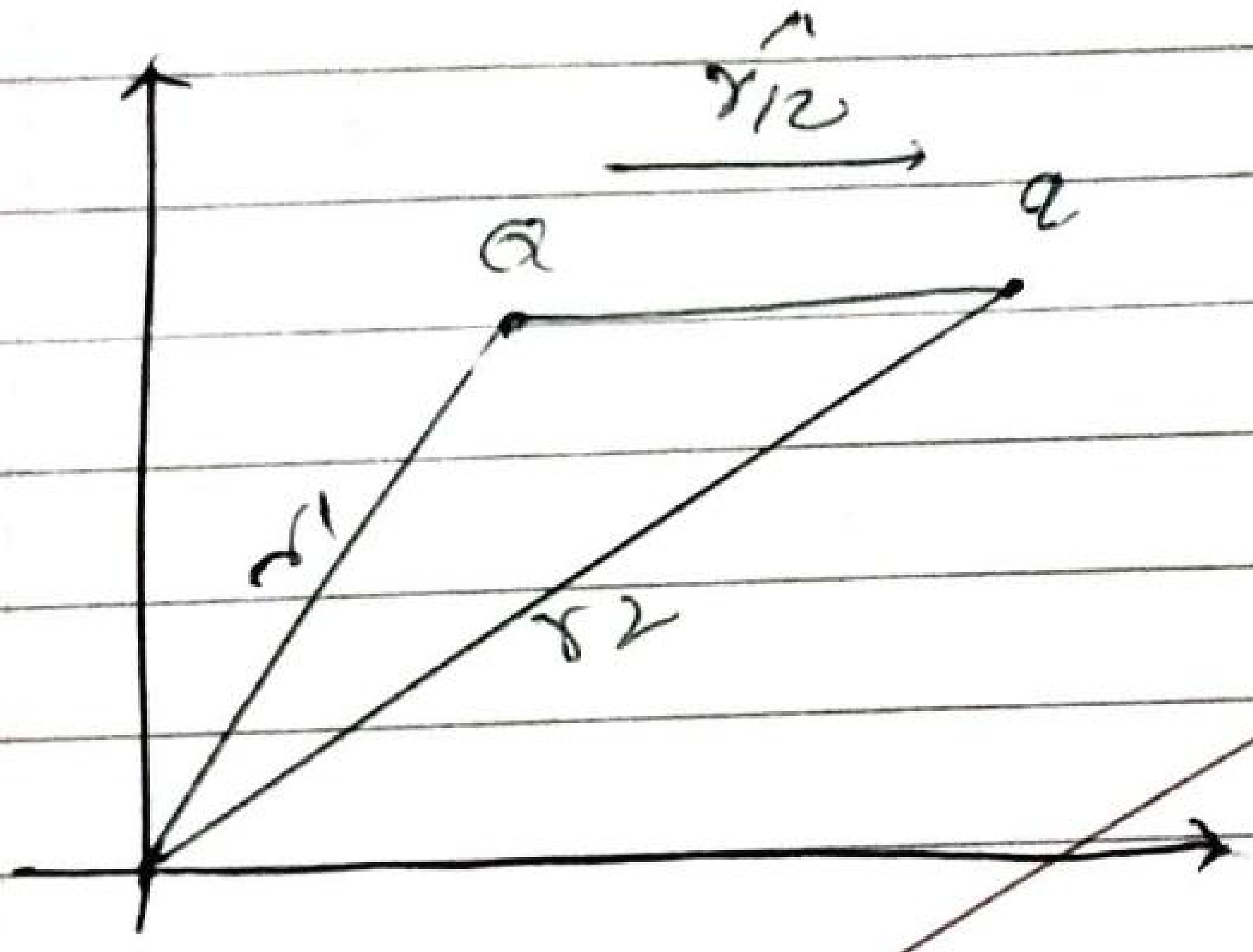
$$\varepsilon_m = \varepsilon_r \varepsilon_0$$

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

$$E_m = \frac{1}{\varepsilon_r} \times \frac{q}{4\pi\varepsilon_0 r^2}$$

$$E_m = \frac{E_0}{\varepsilon_r}$$

☞ Vector form of EFI



$$\vec{F} = \frac{KQq}{r^2} \hat{r}_{12}$$

$$\hat{r}_{12} = \frac{\vec{r}_{12}}{|\vec{r}_{12}|}$$

$$\hat{r}_{12} = \frac{\vec{r}_{12}}{r}$$

$$\vec{F} = \frac{KQq}{r^2} \times \frac{\vec{r}_{12}}{r}$$

$$\vec{F} = \frac{KQq}{r^3} \vec{r}_{12}$$

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

$$\vec{E} = \frac{KQ\cancel{q}}{r^3} \frac{\vec{r}_{12}}{\cancel{q}}$$

$$\vec{E} = \frac{KQ\vec{r}_{12}}{r^3}$$

$$\boxed{\vec{E} = \frac{KQ\vec{r}_{12}}{|\vec{r}_{12}|^3}}$$

$\vec{r_{12}} = (-8-2)\hat{i} + (7-3)\hat{j} + (4-7\hat{k})$

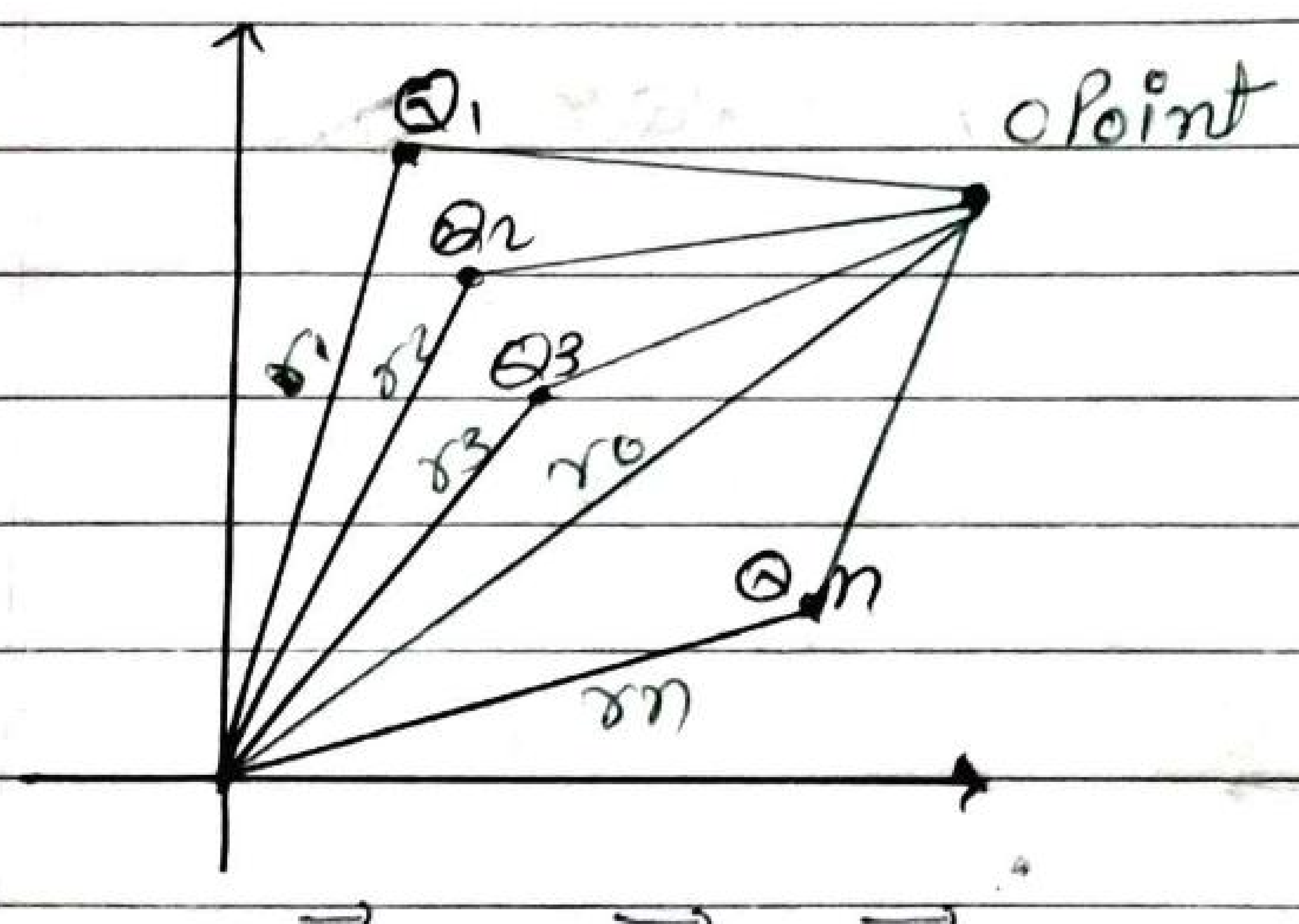
Ques→① A charge of 3 μC placed at point A(2, 3, 7). find EFI due to this charge at Point B(−8, 7, 4)

→ $\vec{E} = \frac{KQ}{|\vec{r_{12}}|^3} (\vec{r_{12}})$

$\vec{E} = \frac{9\times10^9 \times 3\times10^{-6}}{(\sqrt{5}\,5)^3} (-10\hat{i} + 4\hat{j} - 3\hat{k})$

$\vec{E} = \frac{27\times10^3}{625\times\sqrt{5}} (-10\hat{i} + 4\hat{j} - 3\hat{k})$

☞ Super position principal for EFI



$\vec{f_{net}} = \vec{f_{01}} + \vec{f_{02}} + \text{------} \vec{f_{0n}}$

$\vec{E_{net}} = \vec{E_1} + \vec{E_2} + \vec{E_3} \text{-----} \vec{E_n}$

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

$\vec{E_1} = \frac{KQ_1(\vec{r_{01}})}{|\vec{r_{01}}|^3}$, $\vec{E_2} = \frac{KQ_2(\vec{r_{02}})}{|\vec{r_{02}}|^3}$

$\vec{E_n} = \frac{KQ_n(\vec{r_{0n}})}{|\vec{r_{0n}}|^3}$

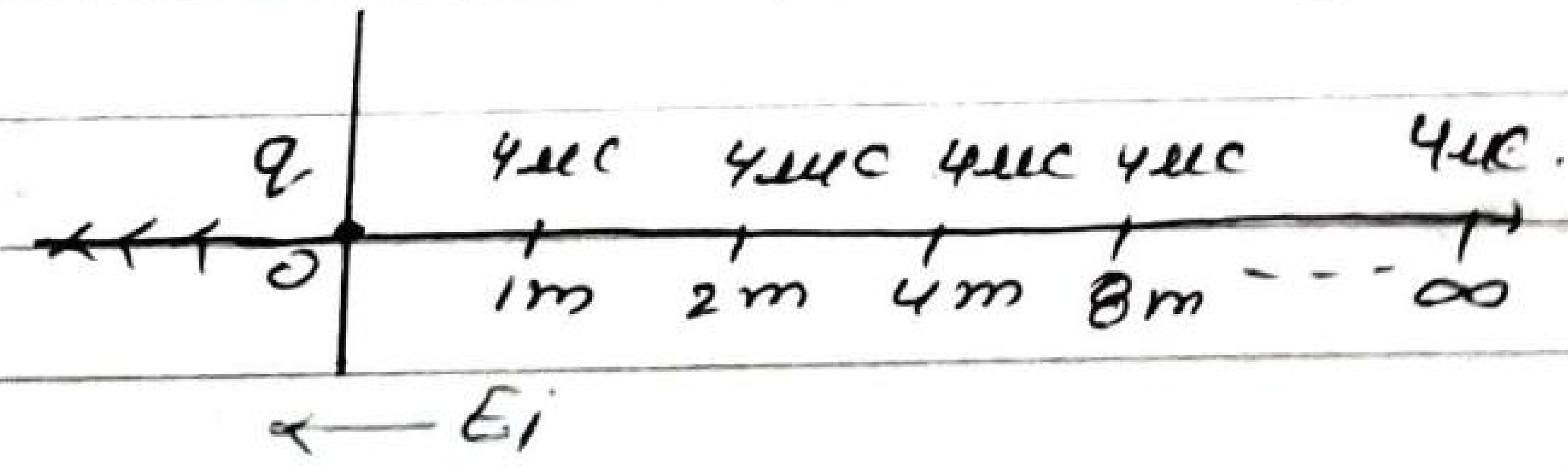
$$\vec{E}_{net} = \frac{KQ_1}{|\vec{r}_{01}|^3}(\vec{r}_{01}) + \cdots \frac{KQ_n(\vec{r}_{0n})}{|\vec{r}_{0n}|^3}$$

$$= K\left[\frac{Q_1}{|\vec{r}_{01}|^3}(\vec{r}_{01}) + \cdots \frac{Q_n}{|\vec{r}_{0n}|^3}(\vec{r}_{0n})\right]$$

$$\vec{E}_{net} = K\sum_{i=1}^{n} \frac{Q_i}{|\vec{r}_{0i}|^3}(\vec{r}_{0i})$$

☆ Que→① infinity charge of $4\mu C$ are placed at 1m, 2m, 4m, 8m ... ∞ then find out E-F-I at origin.

→



$$E_{net} = E_1 + E_2 + E_3 + E_4 \cdots E_\infty$$

$$E_1 = \frac{KQ}{r^2} = \frac{K \times 4\mu C}{(1)^2}, \quad E_2 = \frac{K \times 4\mu C}{(2)^2}$$

$$E_3 = \frac{K \times 4\mu C}{(4)^2}, \quad E_\infty = \frac{K \times 4\mu C}{(\infty)^2}$$

$$E_{net} = \frac{K4\mu C}{1} + \frac{K4\mu C}{4} + \frac{K4\mu C}{16} + \frac{K4\mu C}{64} \cdots 0$$

$$E_{net} = K \cdot 4\mu C\left[1 + \frac{1}{4} + \frac{1}{16} + \frac{1}{64} \cdots \infty\right]$$

$$G.P = a, ar, ar^2, ar^3 \cdots ar^{n-1}$$

$$Sum = \frac{a}{1-r}$$

Note → Direction of EF ~~due~~ will be ... (faded)

$$E_{net} = K \times 4 \times \mu C \left[\frac{1}{1-\frac{1}{4}} \right]$$

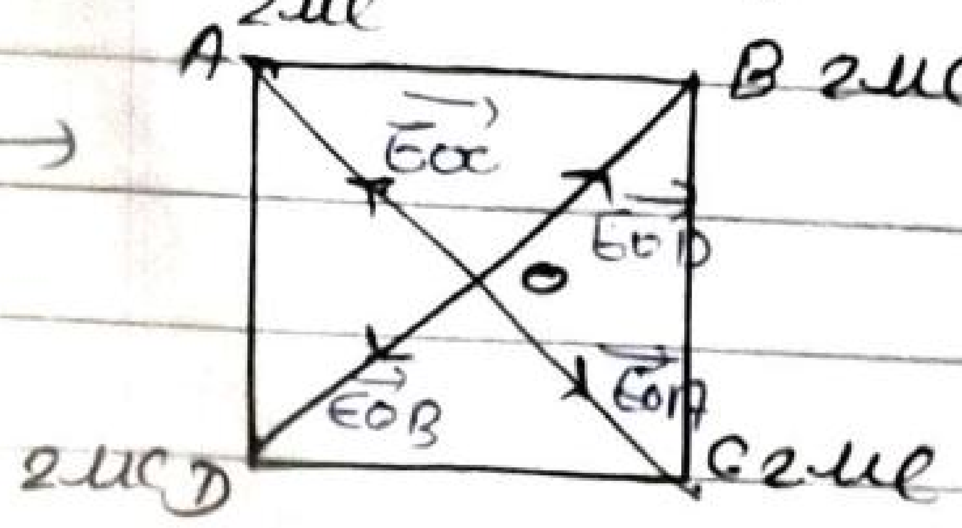
$$= K \times 4 \mu C \left[\frac{1}{\frac{3}{4}} \right]$$

$$E_{net} = K \times 4 \times 10^{-6} \left[\frac{4}{3} \right]$$

$$= 9 \times 10^{9} \times 4 \times 10^{-6} \times \frac{4}{3}$$

$$\boxed{E_{net} = 48 \times 10^{3}\ N/C}$$

Que → (2) Four charges of $2\mu C$ are placed at the ~~centre~~ corners of a square. then find out EFI at the centre of square (i.e intersecting point of diagonals). Given that side of square is 2m.



$AC = BD = 2\sqrt{2}$

$AO = CO = DO = BO = \sqrt{2}$

$E_{OA} = \frac{Kq}{2} = K \times 10^{-6}\ N/C$

$E_{OB} = E_{OC} = E_{OD} = K \times 10^{-6}$

$\vec{E_O} = \vec{E_{OA}} + \vec{E_{OB}} + \vec{E_{OC}} + \vec{E_{OD}}$ — (1)

$\vec{E_{OA}}$ and $\vec{E_{OC}}$ are opposite vector → hence → $\vec{E_{OA}} = -\vec{E_{OC}}$

$\vec{E_{OB}}$ and $\vec{E_{OD}}$ are opposite vector hence → $\vec{E_{OB}} = -\vec{E_{OD}}$

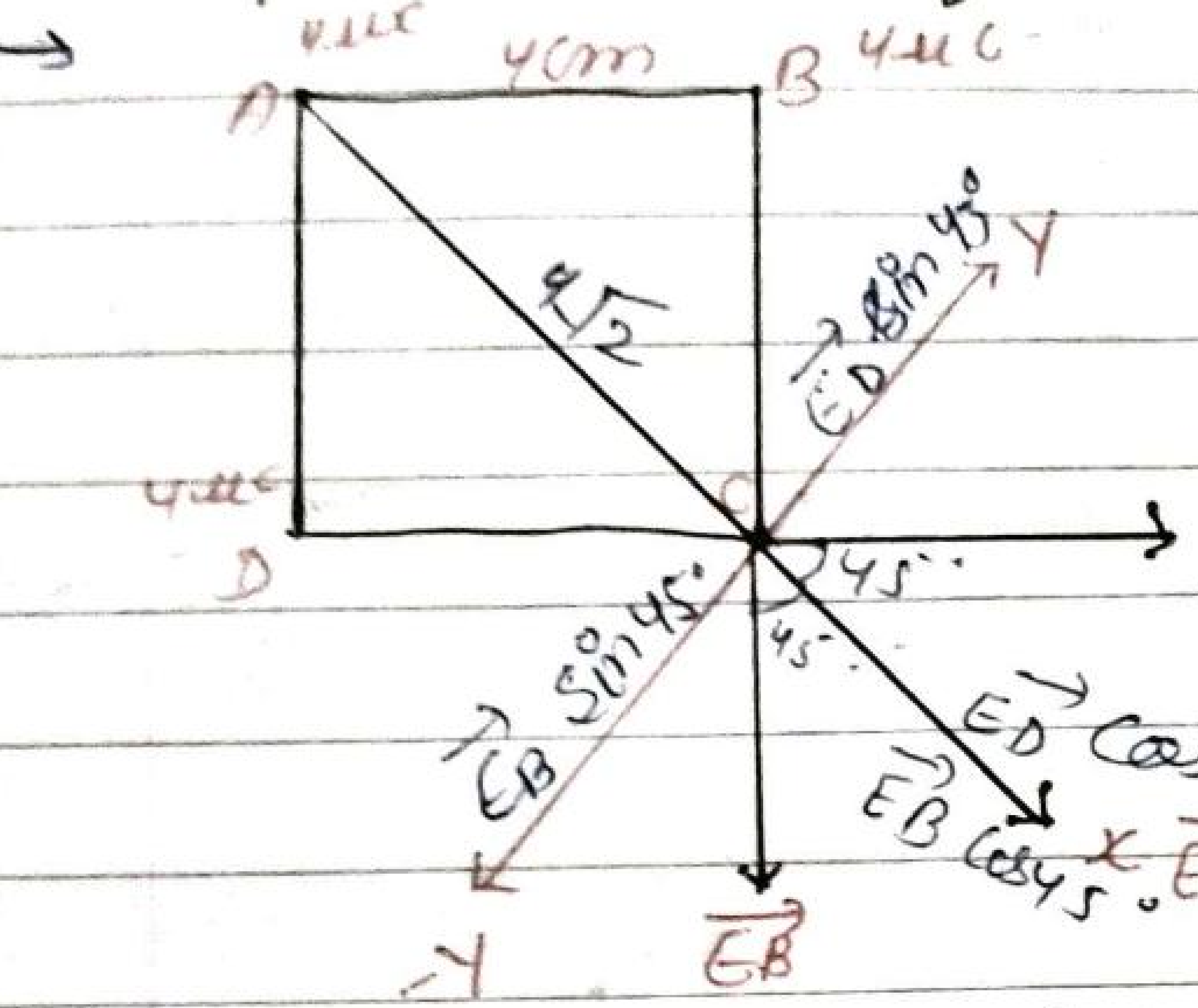
3.3×10^{4}

$$\vec{E_O} = -\vec{E_{OC}} - \vec{E_{OD}} + \vec{E_{OC}} + \vec{E_{OD}}$$

$$\vec{E_O} = 0$$

Que → ⑨ ~~four~~ three charges of 4μc are placed on corners of a square ABCD of side 4cm. find EFI at corners "C".

→



$$\vec{E_D} = \frac{K \times 4 \times 10^{-6}}{(4)^2 \times 10^{-4}}$$

$$\vec{E_A} = \frac{K \times 4 \times 10^{-6}}{(4\sqrt{2})^2 \times 10^{-4}}$$

$$\vec{E_B} = \frac{K \times 4 \times 10^{-6}}{(4)^2 \times 10^{-4}}$$

$$E_y = \vec{E_D}\sin 45° - \vec{E_B}\sin 45°$$

$$E_y = |\vec{E_D}| = |\vec{E_B}|$$

$$\vec{E_y} = 0$$

$$E_x = \vec{E_A} + \vec{E_B}\cos 45° + \vec{E_D}\cos 45°$$

$$E_{net} = E_x = \frac{K \times 4 \times 10^{-6}}{16 \times 2 \times 10^{-4}} + \frac{K \times 4 \times 10^{-6}}{16 \times 10^{-4}} \times \frac{1}{\sqrt{2}} + \frac{K \times 4 \times 10^{-6}}{16 \times 10^{-4}} \times \frac{1}{\sqrt{2}}$$

$$= \frac{K \times 4 \times 10^{-6}}{16 \times 10^{-4}} \left(\frac{1}{2} + \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}} \right)$$

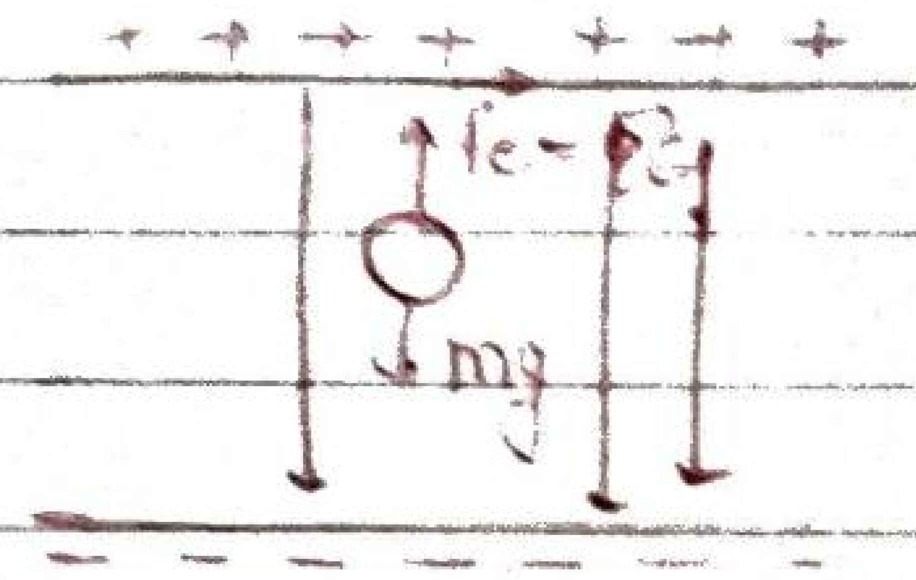
$$= \frac{4 \times 9 \times 10^{9} \times 10^{-6} \times 10^{4}}{16} \left(\frac{\sqrt{2} + 2 + 2}{2\sqrt{2}} \right)$$

$$E_{net} = \frac{9}{8\sqrt{2}} \times 10^{7} (4 + \sqrt{2})$$

Note → $\vec{F} = q\vec{E}$

Que-(4) An oil drop of charge equal to $12e^{\ominus}$ is droped in an field of 2.5×10^5 N/C. If oil drop is in equilibrium than find out radius of oil drop. Given that density of oil drop is 2.5×10^3 kg/m³

→



$f_{net} = 0$

$mg - f_e = 0$

$mg = f_e$

$mg = q\vec{E}$

$q = ne$

$q = 12 \times 1.6 \times 10^{-19} = 19.2 \times 10^{-19}$

$\vec{E} = 2.5 \times 10^5$ N/C

$\vec{f_e} = 2.5 \times 10^5 \times 19.2 \times 10^{-19}$

$M = \frac{2.5 \times 10^5}{10} \times 19.2 \times 10^{-19}$

$d \times v = 2.5 \times 10^4 \times 19.2 \times 10^{-19}$

$v = \frac{2.5 \times 10^4 \times 19.2 \times 10^{-19}}{2.5 \times 10^3}$

$v = 19.2 \times 10^{-18}$

$v = \frac{4}{3}\pi r^3$

$\frac{4}{3}\pi r^3 = 19.2 \times 10^{-18}$

$r^3 = \frac{19.2 \times 3 \times 10^{-18}}{4 \times \frac{22}{7}}$

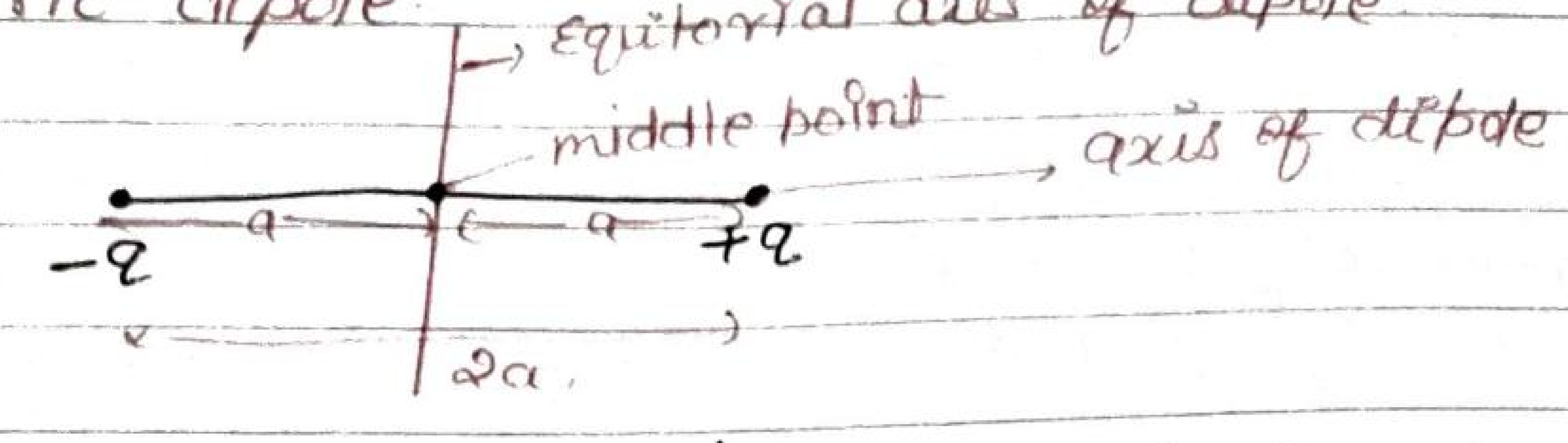
$r^3 = \frac{19.2}{88} \times 21 \times 10^{-18}$

$r = \left[\left(\frac{19.2}{88}\right) \times 21 \times 10^{-18}\right]^{\frac{1}{3}}$ m.

Note → length of dipole always assumed ~~to~~ 2a.

Electric dipole

→



→ Electric dipole is an arrangment in which two charges of opposite nature ~~present~~ and same magnitude are placed at constant distance.

→ Axis of dipole → line joing the both charges is known as electric dipole axis

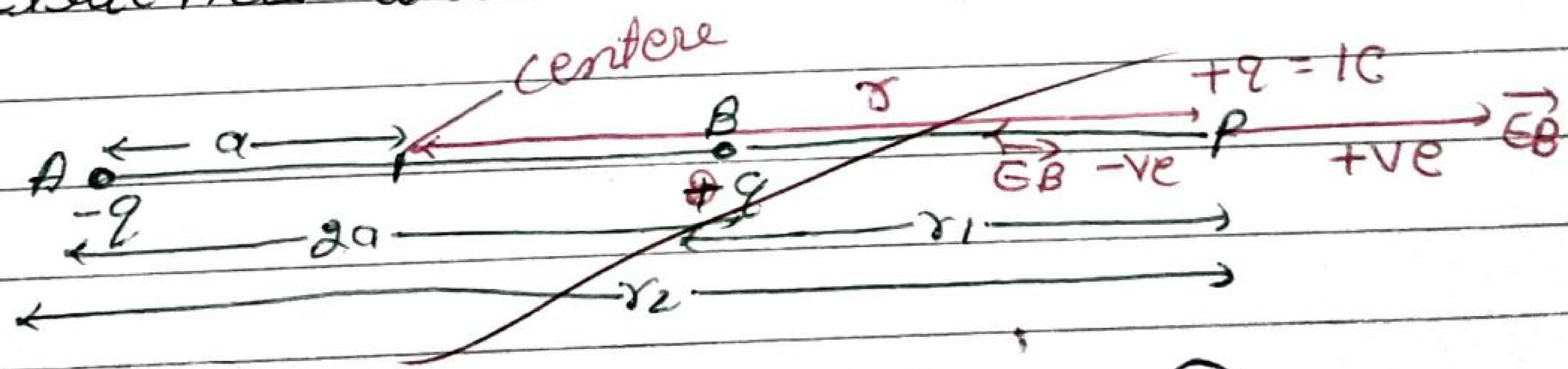
→ Equitorial axis of dipole → line segment ⊥ to the axis of dipole and passing through a middle point of dipole

* Dipolemoment → $\vec{p} = q \times \vec{2a}$

Direction → -ve to +ve.

Electric field due to Electric dipole.

① Electric field due to electric dipole on Axis



$E_B = \frac{Kq}{r_1^2}$ — ①, $E_A = \frac{Kq}{(r_2)^2}$ — ②

$\vec{E}_{net} = \vec{E}_A + \vec{E}_B$

$= \frac{-Kq}{r_2^2} + \frac{Kq}{r_1^2}$

$\vec{E}_{net} = Kq\left(\frac{1}{r_1^2} - \frac{1}{r_2^2}\right)$ — ③

Scanned by TapScanner

$r_1 = r - a$ $\qquad$ $r_2 = r + a$

$OP = OB + BP$ $\qquad$ $AP = AO + OP$

$r = a - r_1$ $\qquad$ $r_2 = a + r$

$r_1 = r - a$.

$$E_{net} = kq\left(\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right)$$

$$E_{net} = kq\left(\frac{(r+a)^2 - (r-a)^2}{(r-a)^2(r+a)^2}\right)$$

$$E_{net} = kq\left(\frac{r^2 + a^2 + 2ar - r^2 - a^2 + 2ar}{(r^2 - a^2)^2}\right)$$

$$E_{net} = \frac{kq \times 4ar}{(r^2 - a^2)^2}$$

$$E_{net} = \frac{2kq \times 2a \times r}{(r^2 - a^2)^2}$$

$$E_{net} = \frac{2kPr}{(r^2 - a^2)^2}$$

$r >>>>> a$

$r^2 >>>>>> a^2$

$r^2 - a^2 \simeq r^2$

$$E_{net} = \frac{2kPr}{r^4}$$

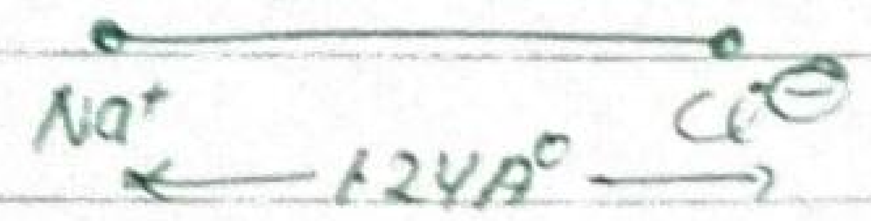
$$E_{nt} = \frac{2kP}{r^3}$$

$$E_{axis} = \frac{2kP}{r^3}$$

Que-① find out electric field due to NaCl crystal at a distance of 30cm at its axis. It given that Bond length of NaCl atom is 1.24A°

$Na^{\oplus} \xrightarrow{1e^-} Cl^{\ominus}$

→



$2a = 1.24A^{\circ} = 1.24 \times 10^{-10} M$

$r = 30cm = 30 \times 10^{-2}$

$q = nC$

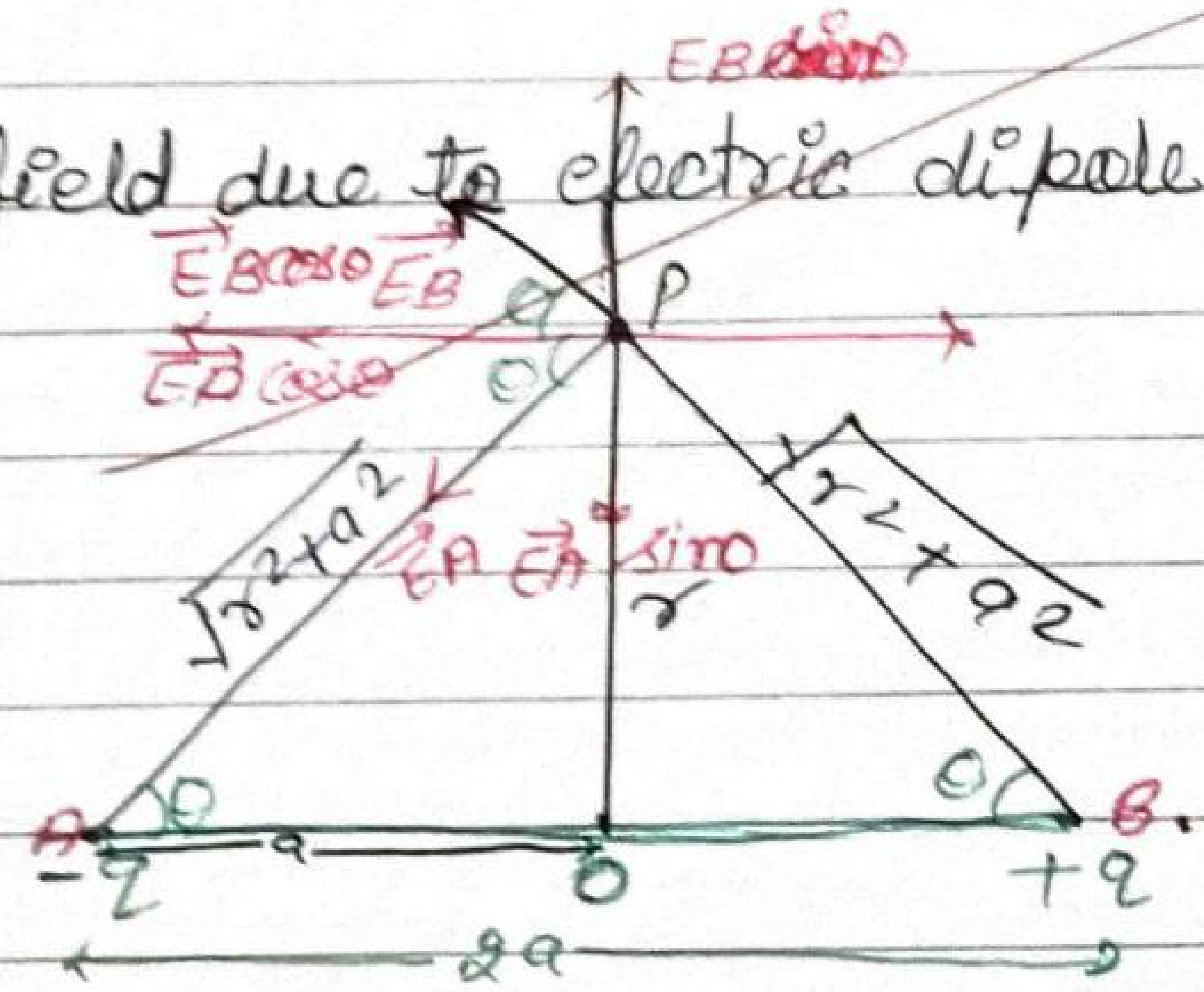
$q = 1 \times 1.6 \times 10^{-19}$

$$E = \frac{2KP}{r^3} = \frac{2 \times 9 \times 10^{9} \times 1.6 \times 10^{-19} \times 1.24 \times 10^{-10}}{(30 \times 10^{-2})^3}$$

$$= \frac{2 \times 9 \times 1.6 \times 1.24 \times 10^{-20}}{9 \times 3 \times 10^{-3}}$$

$$E = \frac{2}{3} \times \frac{1.6}{10} \times \frac{1.24}{100} \times 10^{-17}$$

② Electric field due to electric dipole at its equitorial point.



$$E_{net} = \sqrt{Ex^2 + Ey^2}$$

$$Ex = E_A\cos\theta + E_B\cos\theta \quad \text{—①}$$

$$Ey = E_B\sin\theta - E_A\sin\theta.$$

$$E_A = \frac{Kq}{(\sqrt{r^2+a^2})^2} = \frac{Kq}{(r^2+a^2)}$$

$$E_B = \frac{kq}{(\sqrt{r^2+a^2})^2} = \frac{kq}{(r^2+a^2)}$$

$$E_A = E_B = E$$

→ $E_x = E\cos\theta + E\cos\theta$

$E_x = 2E\cos\theta$

$E_y = E\sin\theta - E\sin\theta = 0$

→ $E_{net} = \sqrt{E_x^2 + 0^2}$

$E_{net} = E_x$

$E_{net} = 2E\cos\theta$

$$E_{net} = \frac{2kq}{(r^2+a^2)} \times \cos\theta$$

→ In Δ OAP →

$$\cos\theta = \frac{B}{H} = \frac{a}{\sqrt{r^2+a^2}}$$

$$E_{net} = \frac{2kq}{(r^2+a^2)} \times \frac{a}{(r^2+a^2)^{\frac{1}{2}}}$$

$$E_{net} = \frac{k \times q \times 2a}{(r^2+a^2)^{3/2}}$$

$$E_{net} = \frac{kP}{(r^2+a^2)^{3/2}}$$

→ $$E_{equi} = \frac{kP}{(r^2+a^2)^{3/2}}$$

$r >>>> a$

$r^2 >>>> a^2$

$r^2 + a^2 \simeq r^2$

$$E_{net} = \frac{kP}{(r^2)^{\frac{3}{2}}}$$

$$\boxed{E_{net} = \frac{kP}{r^3}}$$

Electric field lines

- Electric field lines are ~~thes~~ a way of pictorially mapping the electric field around a configuration of charge.

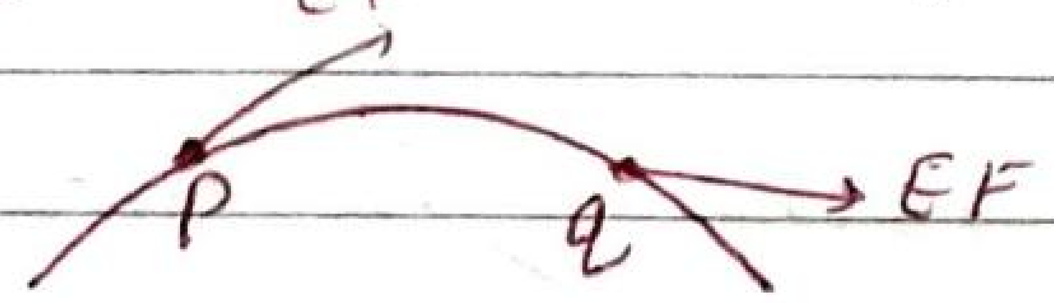
An electric field line. is in general a curve drawn in such a way that the tangent to it at each Point is in the direction of net field at that point.

- Properties of electric field lines.

1 Electric field lines are the path of motion of positive charge.

2 Electric field lines are may be straight line or Curve.

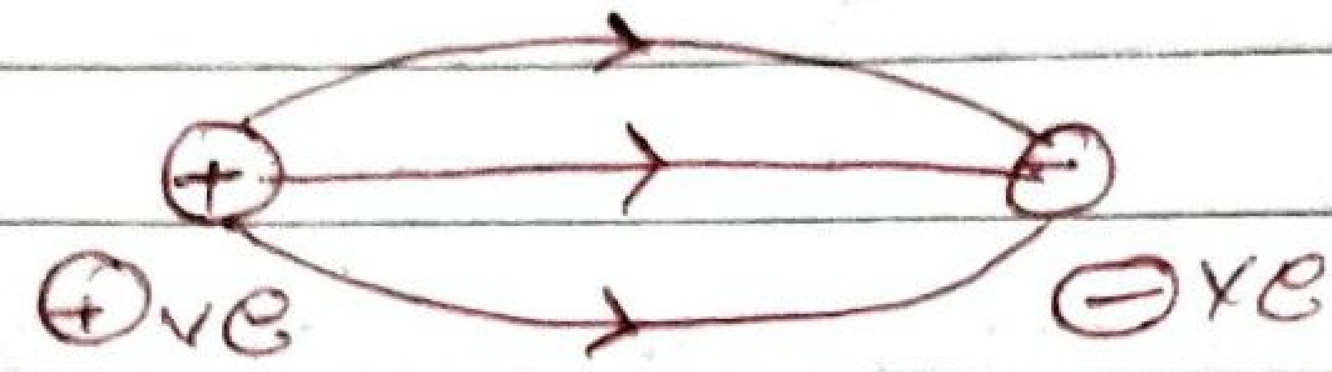
3 Direction of Electric field on a Electric field line is in the direction of tengent at a given point



4 Electric field lines do not intersect each other because if electric field lines intersect each other then there will be two direction of Efield which is not possible.

5 For positive point Efield charge will be outward but for negative point Electric field charge will be inward.

6. For electric dipole Electric field lines will be ⊕ve to ⊖ve.



7. EFL do not form close loops.
8. Density of EFL is proportional to EField.

$EF_1 >> EF_2$

* EFL intensity is greater at place where Efield lines are more and smaller or less where EFL are not so much.

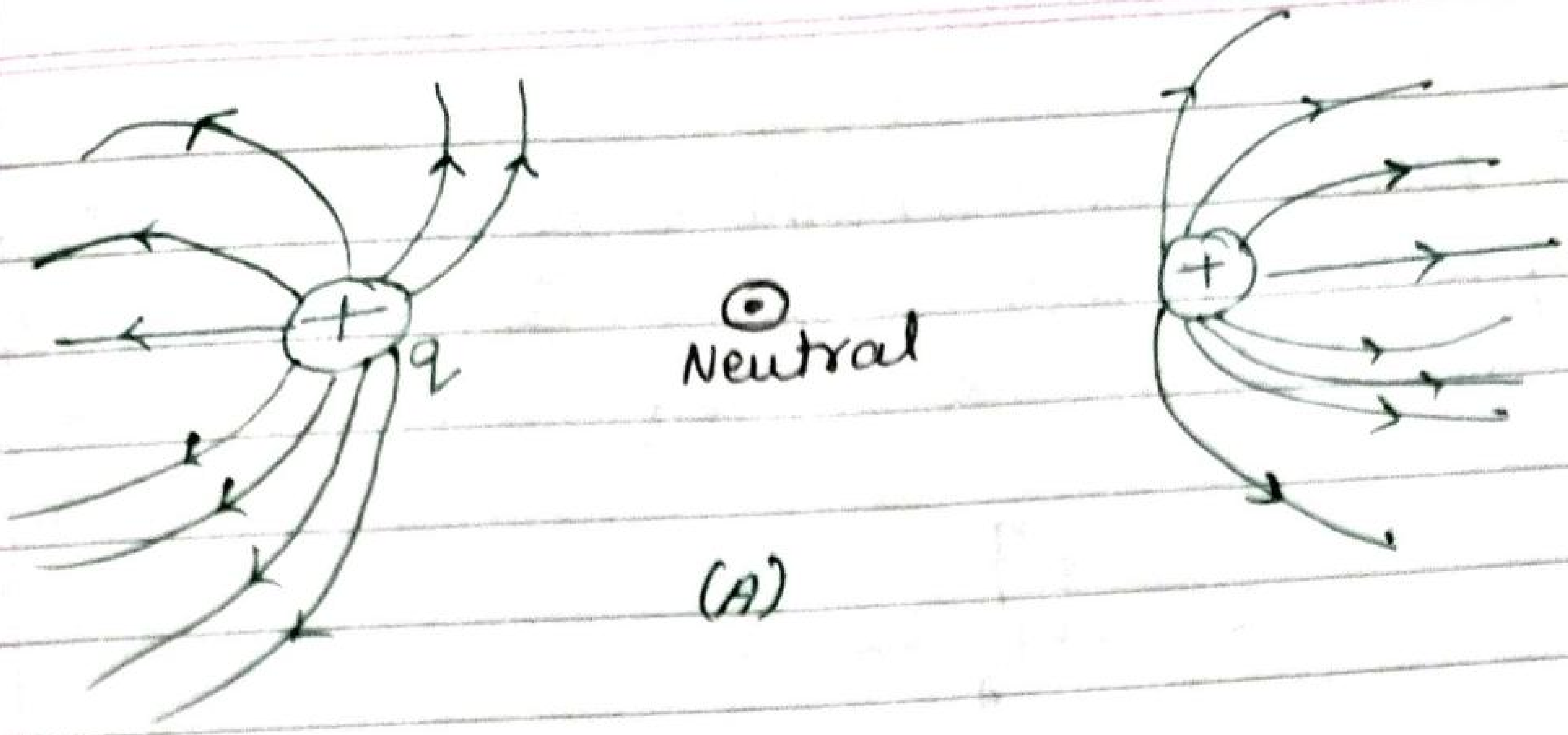
Natutral Point → Neutral point is a point in a system where the EFL force and its intensity is zero. It must be in equilib. condition

So $F_{net} = 0$

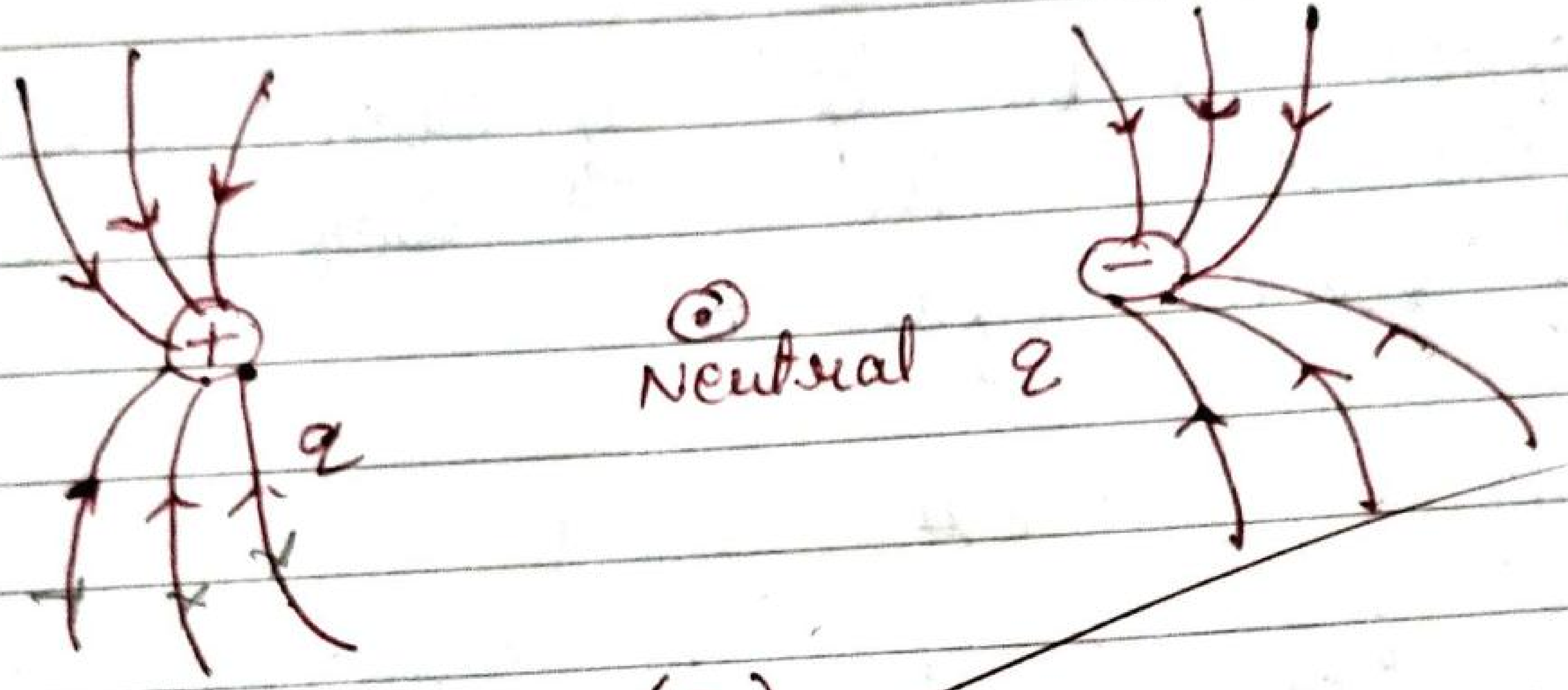
$$E = \frac{F}{q}$$

$$E = 0$$

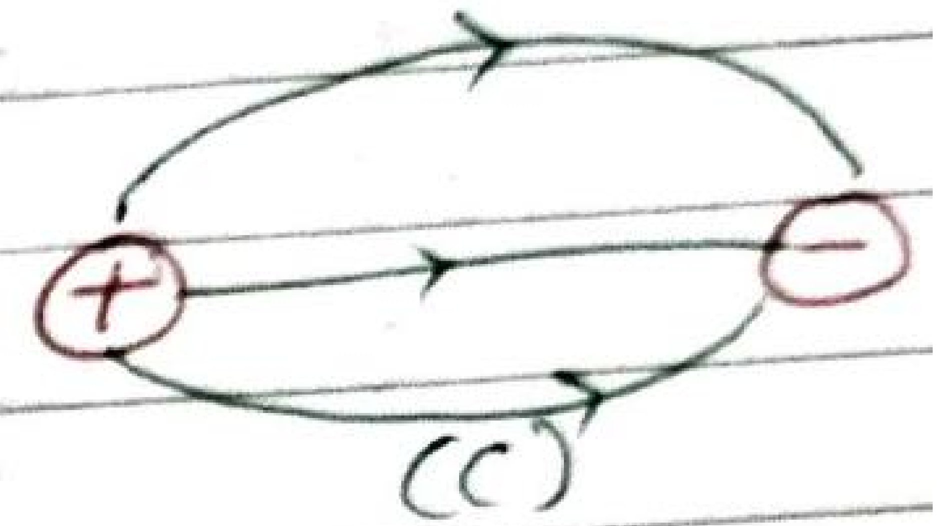
Scanned by TapScanner



(A)



(B)



(C)

Conditions –

① Neutral point for equal magnitude charge is at mid point.

② Neutral point for unequal magnitude charge is by the smaller charge.

So, $\frac{r_1}{r_2} = \sqrt{\frac{Q_1}{Q_2}}$