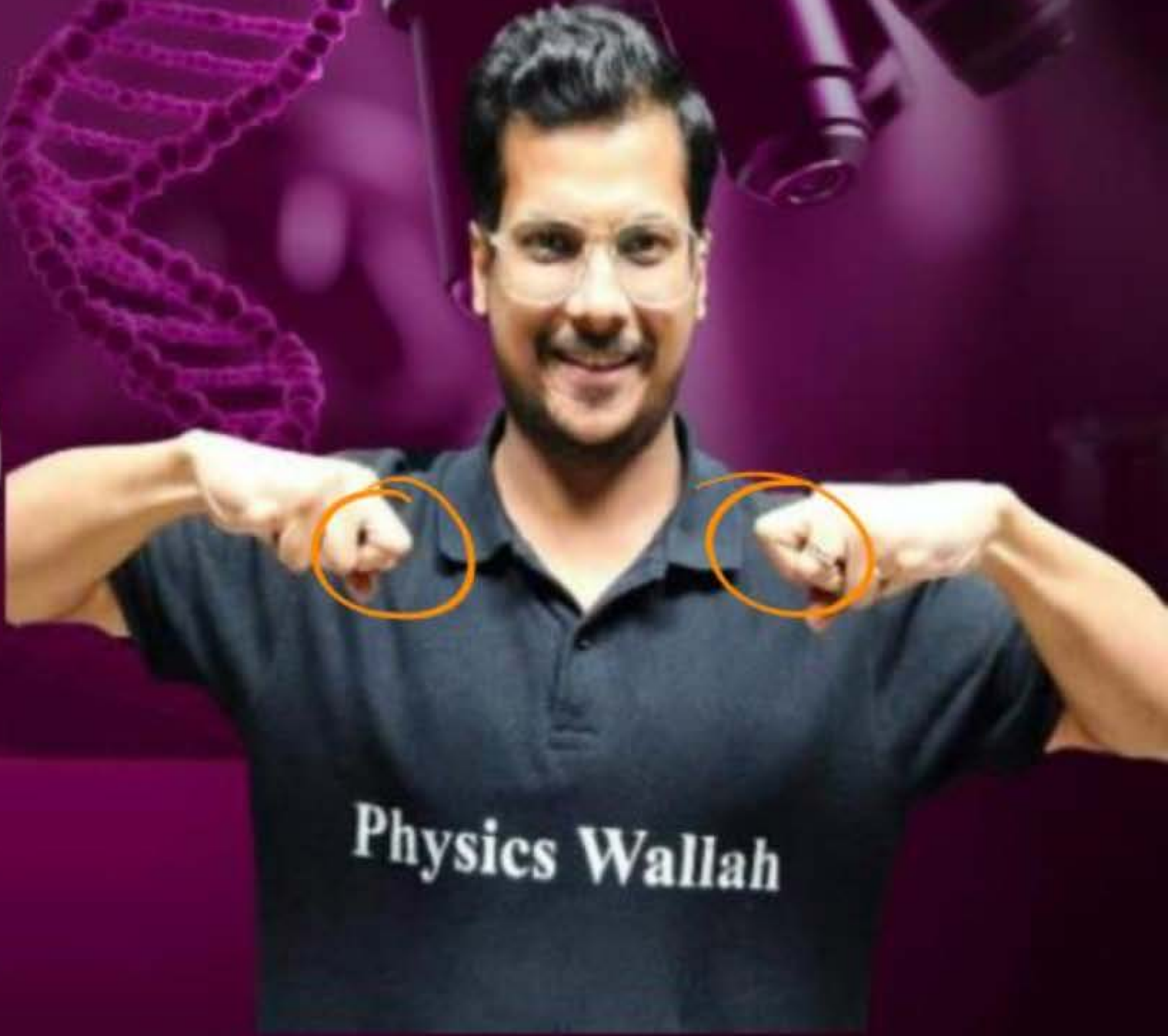
PRACHAND NEET

ONE SHOT

PHYSICS

ELECTRIC CHARGES AND FIELDS

TANUJ BANSAL SIR (TBS)



Topics *to be covered*

1. Charge, Methods of Charging
2. Coulomb's Law, Superposition Principle
3. Electric Field, Electric Dipole
4. Electric Flux, Gauss Law

TABAHI OP in the chat box !!!


PRACHAND SERIES
TELEGRAM CHANNEL
YAKEEN NEET
@PW_YAKEENDROPPER

Importance of 12th Class

- More weightage than 11th Class

2023 → 58% → 29 ques.

2024 → 60% → 30 ques

- Shorter Syllabus than 11th
- Formula Based and Scoring
- You can study here without Tension of 11th
- JEE Mains ke Swaal bhi krenge
- Assertion-Reason, Statement Based Swaal Bhi Krenge
- Surprise – **TBS Capsule** Short Notes at Lecture End

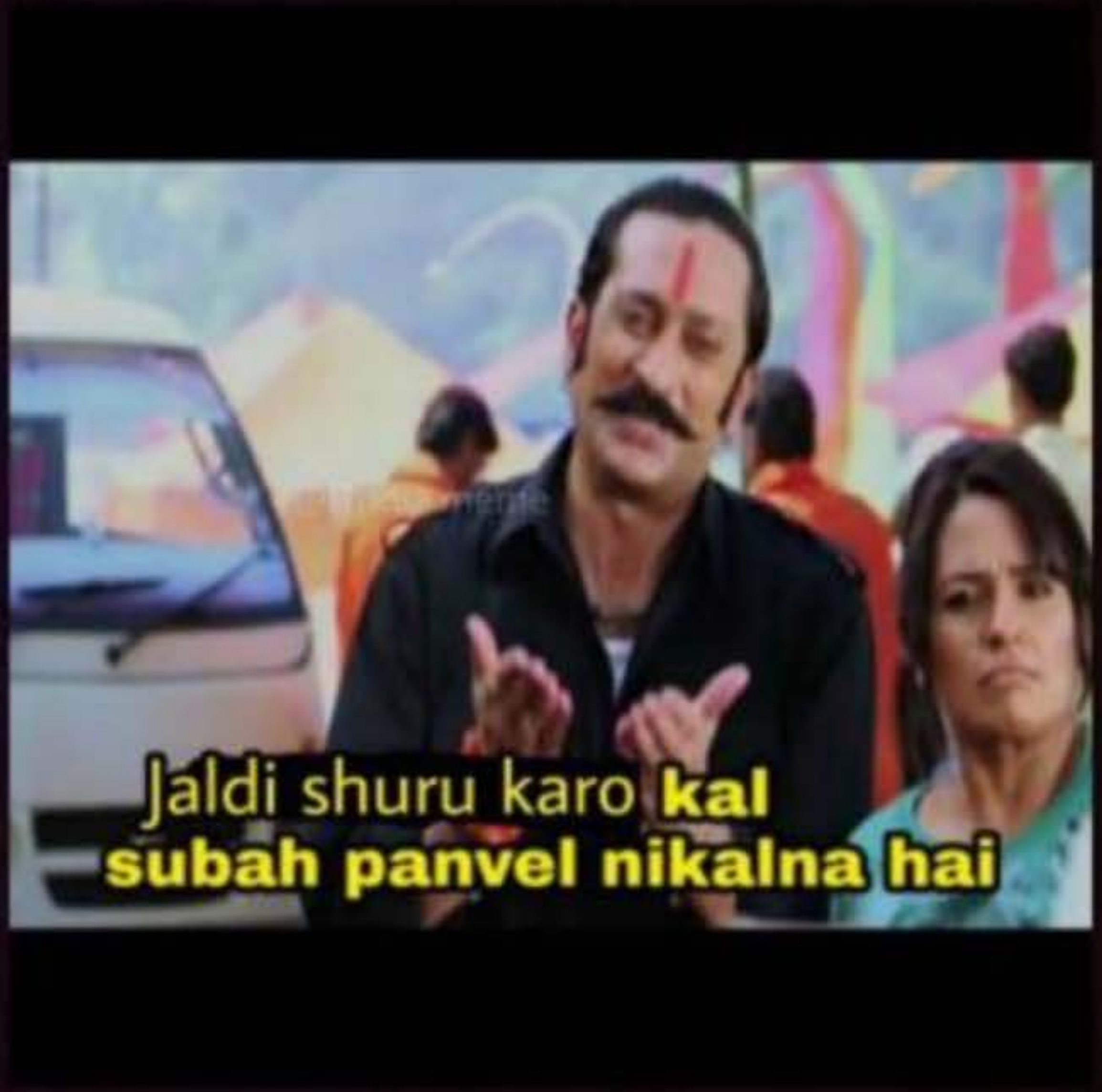
Electrostatics

Charge at rest

① Electric Charges and Fields

② Electrostatic Potential and Capacitance

$\hookrightarrow$ 14 Dec



Weightage of the Chapter

- 2019 to 2024 – Total 14 Questions ✓
- Expected Questions – 2 to 3 ✓
- Basic of Whole electro-magnetism ✓

CHARGE (q or Q)

It is a fundamental property of a matter due to which it experiences and produces electric and magnetic effects.

* SI unit → Coulomb (C)

cgs unit → Stat coulomb = esu = franklin

esu ↓ electrostatic unit

$\boxed{1C = 3\times10^9 \text{ stat-col}}$

cgs unit ↓ Smallest unit

★ Largest unit → Faraday

$\boxed{1F = 96500C}$

Types of Charges

① +ve eg : proton

$q = +e = +1.6\times10^{-19}\,C$

$m = 1.67\times10^{-27}\,kg$

② -ve eg : electron

$q = -e = -1.6\times10^{-19}\,C$

$m = 9.1\times10^{-31}\,kg$

+ve -ve ↳ neutral ⇒ eg : neutron

$q = 0$

$m = 1.67\times10^{-27}\,kg$

Properties of Charge

1. Like charges repel each other and unlike charges attract each other.

$\begin{matrix} + & + \\ - & - \end{matrix} \Big\} \rightarrow$ repel $+ \quad - \Big] \rightarrow$ attract

2. Charge is additive. (scalar) ⇒ with sign

eg :- $3c + 4c = 7c$ eg :- $5c + (-3c) = 2c$

3. Charge of an $\boxed{\text{isolated system}}$ is conserved.

Created × transferable ✓

destroyed ×

4. Charge is <u>invariant</u> but mass is <u>variant</u>.

doesn't change with speed

changes with speed

q_0 (Rest) = 2C

$q \xrightarrow{} v$

$q \to \boxed{q = 2C}$

Same

$$\boxed{m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}} \longrightarrow \text{Rare Chance}$$

$$\boxed{v << c}$$

m_0 = rest mass

m = mass when moving

c = Speed of light in vacuum = 3×10^8 m/s

×

5. Ek Tarfaa Pyaar - Mass can exist without charge, but charge cannot exist without mass.

✓

eg ÷ neutron

mass ✓

Charge ×

eg ÷ proton/electron

Charge ✓

mass ✓

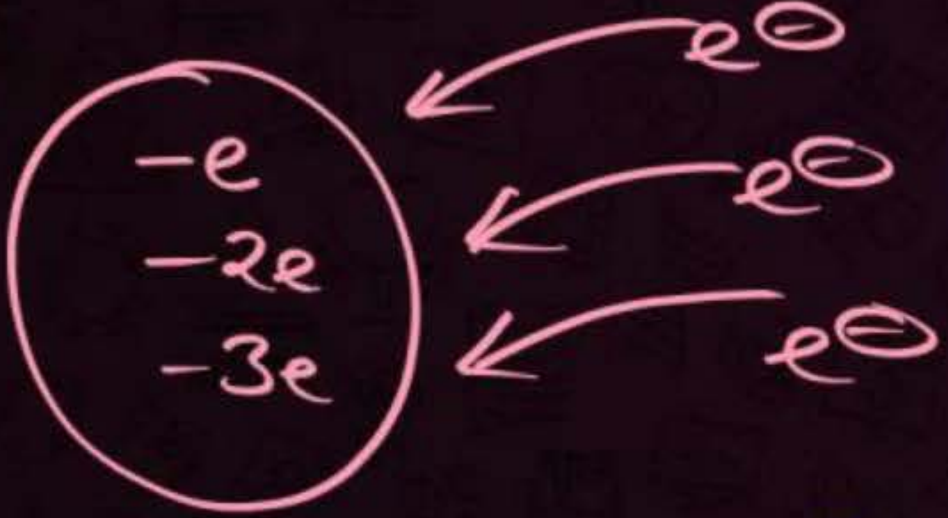
Ek tarfa pyar ki taqat hi kuch aur hoti hai
Auron ke rishton ki tarah yeh do logon
mein nahi bat'ti
Sirf mera haq hai ispe

mass Bina Charge ✓

Charge Bina Mass ×

6. **Charge is quantized-** The charge on any body is integral multiple of an electronic charge. (e)

$$\boxed{q = \pm ne}$$ $n = 0, 1, 2, 3, 4, 5, \ldots$



$q = 5.5e$ × $q = 2.75e$ ×

$q = -3.3e$ × $q = 9.5e$ ×

Soch Bhai Soch

Why protons can’t be transferred?

$\longrightarrow$ easy to transfer ✓

Nucleus. (proton) $\longrightarrow$ difficult ✗

QUESTION

$\cdot q = 2C$

Assertion (A): Charge is invariant with speed. ✓

Reason (R): Charge does not depend on speed or frame of reference. ✓

$\rightarrow \cdot q = 2C$

[✓ ①] Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A).

② Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A).

③ Assertion (A) is True, Reason (R) is False.

④ Assertion (A) is False, Reason (R) is True.

QUESTION

$q = 3.2C$ ✓

$q = 3.2e$ ×

Find charge on body in each case:

1) 100 electrons removed $\Rightarrow q = +100e = 100 \times 1.6 \times 10^{-19}\,C = 1.6 \times 10^{-17}\,C$

2) 20 electrons added $\Rightarrow q = -20e = -20 \times 1.6 \times 10^{-19} = -3.2 \times 10^{-18}\,C$

3) 5 electrons removed $\Rightarrow q = +5e$

4) 25 electrons removed $\Rightarrow q = +25e$

5) 2000 electrons added $\Rightarrow q = -2000e$

Darshak Bane Fielder, Fielder Bane Darshak

How many electrons has to be removed from a body to charge it by 1 coulomb?

① ✓ 6.25×10^{18}

② 6×10^{18}

③ 3.25×10^{19}

④ 6.25×10^{19}

$$q = +1C$$

$$q = +ne$$

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

TBS $\boxed{n = 6.25 \times 10^{18} \text{ elec. rem.}}$

$\underline{\underline{\text{1C}}}$

$\rightarrow \frac{625}{100} \times 10^{18}$

$\rightarrow \underline{625 \times 10^{16}}$

$$\underline{\underline{2C}} \longrightarrow 2 \times 6.25 \times 10^{18}$$

$$\Rightarrow 12.5 \times \underline{\underline{10^{18}}}$$

$$3C \Rightarrow 3 \times 6.25 \times \underline{\underline{10^{18}}}$$

$$4\,\mu C = 4 \times 10^{-6} \times 6.25 \times 10^{18}$$

$$= 25 \times 10^{12}$$

QUESTION

A neutral body is charged by $\underline{2\ \text{nC}}$. Find number of electrons transferred from it.

① 6.25×10^{12}

② 12.5×10^{12}

③ 6.25×10^{9}

[✓ ④ 12.5×10^{9}]

$$\underline{2} \times 10^{-9} \times \underline{6.25} \times 10^{18}$$

$$\underline{12.5 \times 10^{9}}$$

Doodh ka Doodh, Lassi ki Lassi

Kaun Sachcha, Kaun Jhootha?

① **Dholu Uncle** says he has charge 3.2×10^{-18} C

Dholu Uncle

$$q = ne$$

$$\underset{2}{\cancel{3.2}}\times\cancel{10^{-18}} = n\times\cancel{1.6}\times\underset{10^{-1}}{\cancel{10^{-19}}}$$

$$2 = n\times 10^{-1}$$

$$2\times 10 = n = \boxed{20}$$ ✓

Doodh ka Doodh, Lassi ki Lassi

Kaun Sachcha, Kaun Jhootha?

② **Alia Bhootni** says she has charge 6.4×10^{-16} C

$$q = ne$$

$$\cancel{6.4} \times \cancel{10}^{-16} = n \times \cancel{1.6} \times \cancel{10}^{-19}$$

4 $\quad$ 10^{-3}

$$4 \times 10^{3} = n$$

$$\boxed{4000 = n}$$ ✓

Alia Ne NEET ka Paper kha Liya!!!

Doodh ka Doodh, Lassi ki Lassi

Kaun Sachcha, Kaun Jhootha? *

③ Jhumru says he has charge 1.6×10^{-20} C

TBS → $q < 1.6 \times 10^{-19}$ C

↓

No check.

⇓

not possible

$$q = ne$$

$$\cancel{1.6} \times \underset{10^{-1}}{\cancel{10^{-20}}} = n \times \cancel{1.6} \times \cancel{10^{-19}}$$

$$n = 10^{-1} = \frac{1}{10} = 0.1 \times$$

$q = 3.2 \times 10^{-25}$ C

×

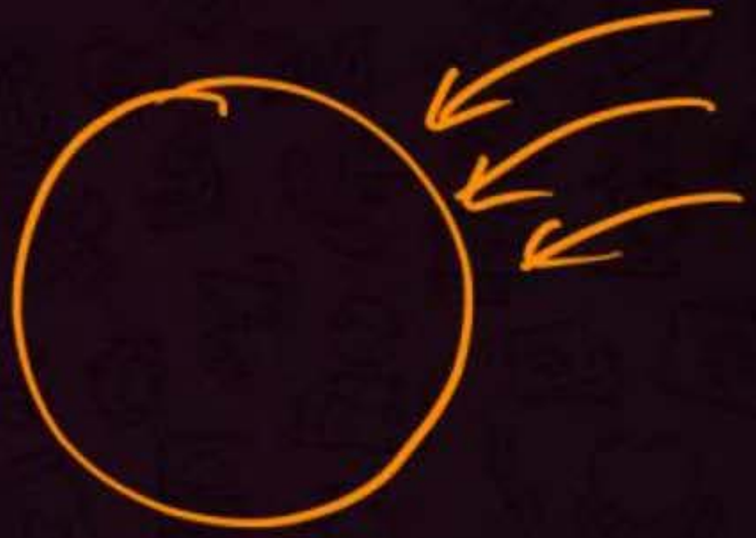
$q = 6.4 \times 10^{-29}$ C

×

Soch Bhai Soch

A neutral body is charged negatively. What happens to its mass?

1. [✓ Increases]
2. Decreases
3. Remains same
4. Can’t predict



$e^{\ominus}$ add

Soch Bhai Soch

A neutral body is charged positively. What happens to its mass?

① Increases

[✓ ②] Decreases

③ Remains same

④ Can't predict

QUESTION

Charge on alpha particle is

① 1.6×10^{-19} C

[✓ ②] 3.2×10^{-19} C

③ 6.4×10^{18} C

④ 3.2×10^{19} C

${}_{2}He^{4}$

$\rightarrow 2e^{\ominus}$ removed

$q = +2e$

$= 2 \times 1.6 \times 10^{-19}$

QUESTION

Charge on deutron is

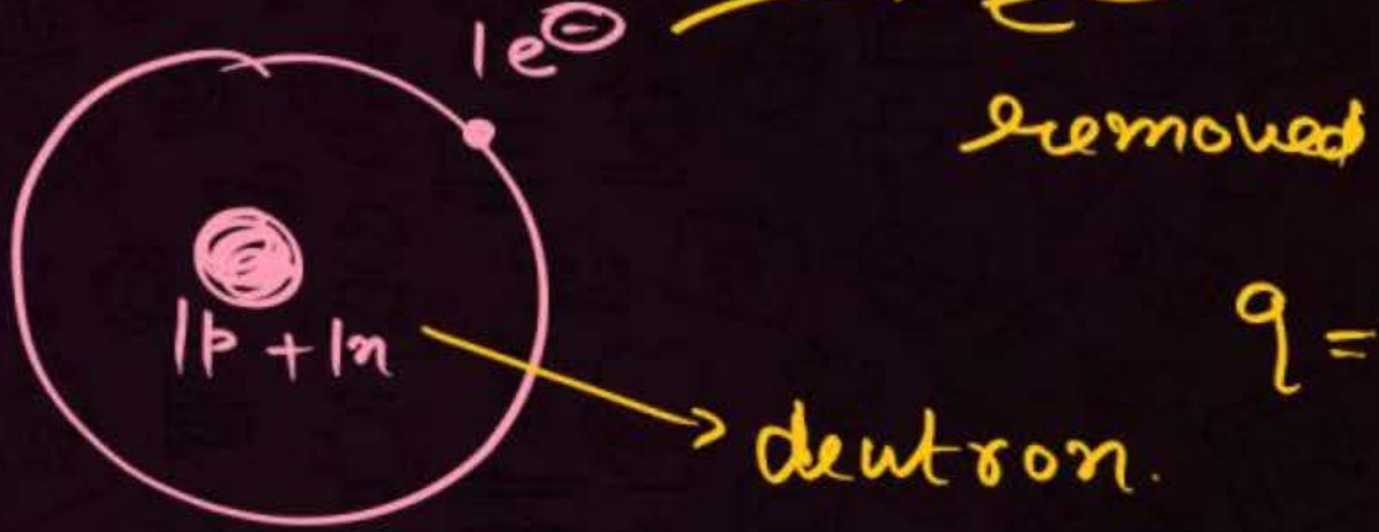
[✓ ① 1.6×10^{-19} C]

② 3.2×10^{-19} C

③ 6.4×10^{18} C

④ 3.2×10^{19} C

$\boxed{{}_1H^2}$ Deutirium atom.



$q = +e$

QUESTION

Assertion (A): Total number of positive ions in nature is constant. × Total q ✓
cons.

Reason (R): In an isolated system charge remains conserved. ✓

1. Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)

2. Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)

3. Assertion (A) is True, Reason (R) is False.

[✓ 4] Assertion (A) is False, Reason (R) is True.

QUESTION

He He^{2+}

↳ α

Assertion (A): Mass of ion is slightly different from its element form.

Reason (R): Ion is formed, when some electrons are removed or added so mass changes.

[✓ ①] Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)

② Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)

③ Assertion (A) is True, Reason (R) is False.

④ Assertion (A) is False, Reason (R) is True.

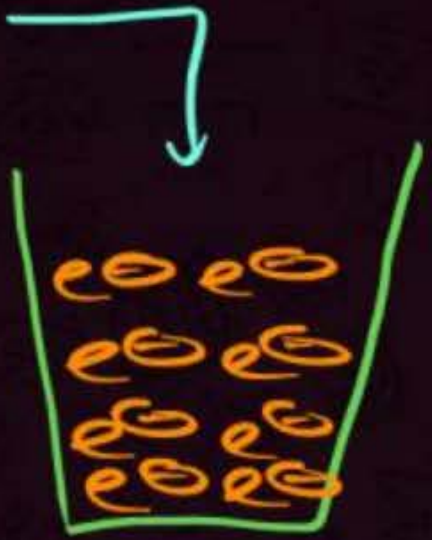
SPECIFIC CHARGE

$\boxed{s = \frac{q}{m}}$

SI unit → $\boxed{\frac{C}{kg}}$

Charge ka Juice

Find the charge on 91 kg of electrons.



Juice → Charge

$$9.1\times10^{-31}\,\text{kg} \longrightarrow -1.6\times10^{-19}\,\text{C}$$

$$1\,\text{kg} \longrightarrow \frac{-1.6\times10^{-19}}{9.1\times10^{-31}}\,\text{C}$$

$$91\,\text{kg} \longrightarrow \frac{-1.6\times10^{\cancel{-19}}}{\cancel{9.1}\times10^{\cancel{-31}}}\times\cancel{91}^{10} \quad 10^{-12}.$$

$$\Rightarrow -1.6\times10^{12}\times10$$

$$\Rightarrow -1.6\times10^{13}\,\text{C} \quad \boxed{\text{Ans}}$$

Juice → Mosambi ×

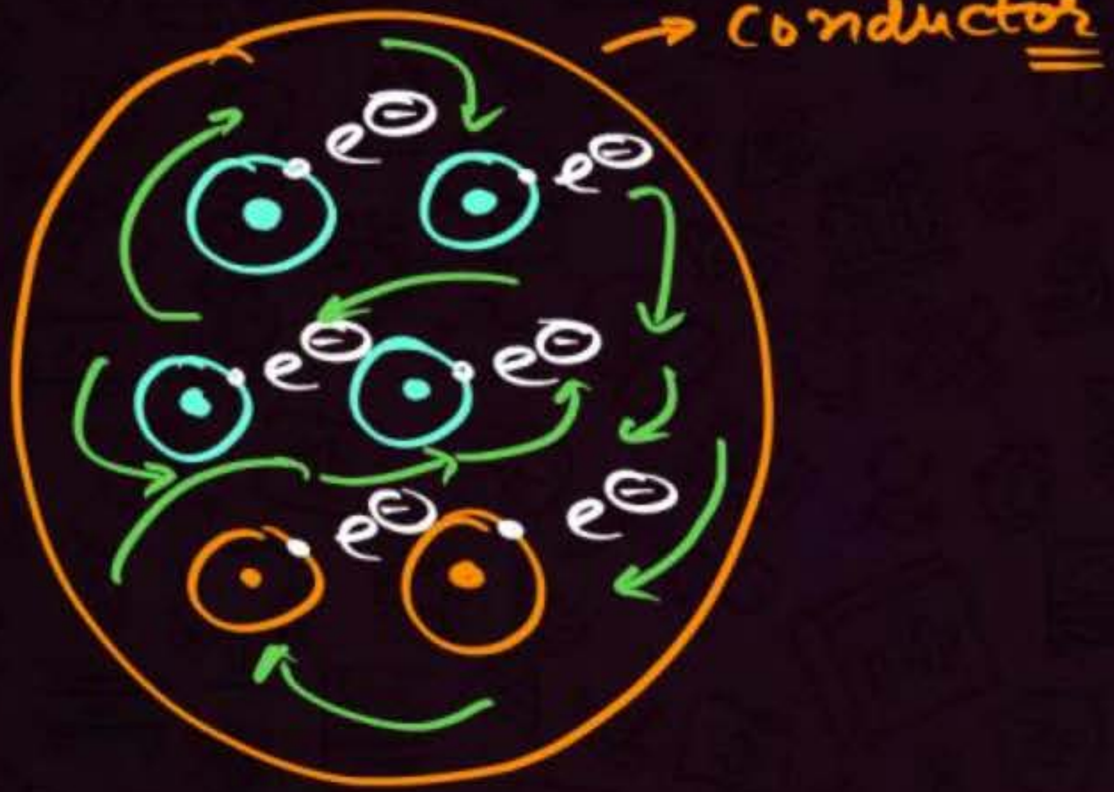
TYPE OF MATERIALS ON THE BASIS OF CHARGE FLOW

① Conductor → easy flow charge move ✓

② Insulators → move ×

③ semi-conductor → limited movement

Charge bnaa Bandar



METHODS OF CHARGING

1. By Rubbing / Friction

- When two bodies are rubbed together, electrons are transferred from one body to another.

- Only for the insulators

- Examples: Glass rod (positive) rubbed with Silk (Negative)

+ $\xrightarrow{e^{\ominus}}$ −

$\overset{(+)}{\text{Fur}} \longrightarrow \overset{(-)}{\text{Ebonite Rod}}$

(rubber)

$\xrightarrow{e^{\ominus}}$

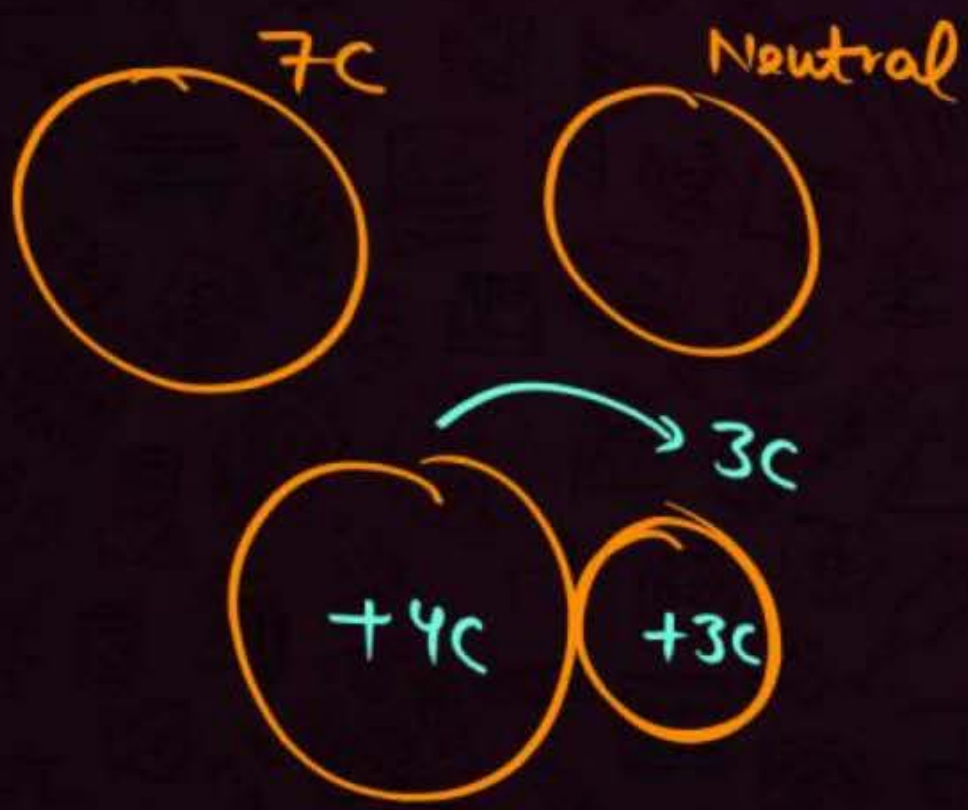
G S

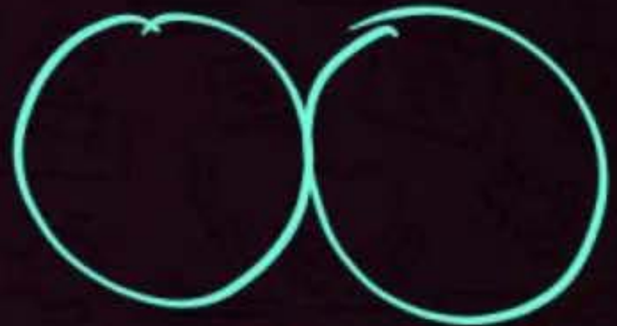
F E

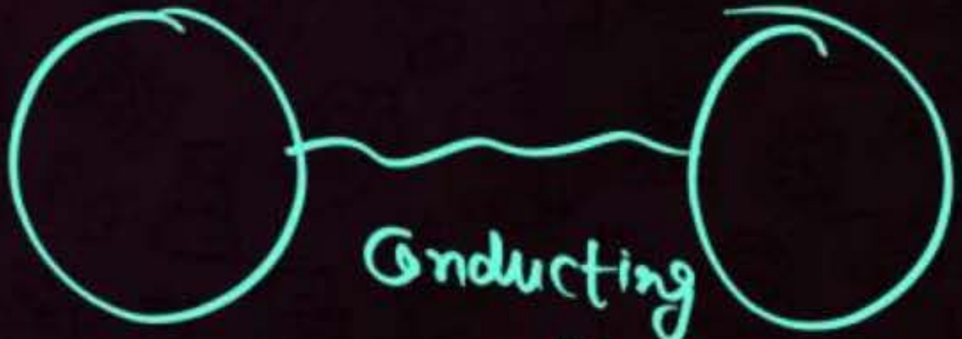
Static Electricity ka Kamaal

2. By Conduction

- Only for conductors
- By touching two conducting bodies or connected through a conducting wire.
- One of the bodies must be charged.

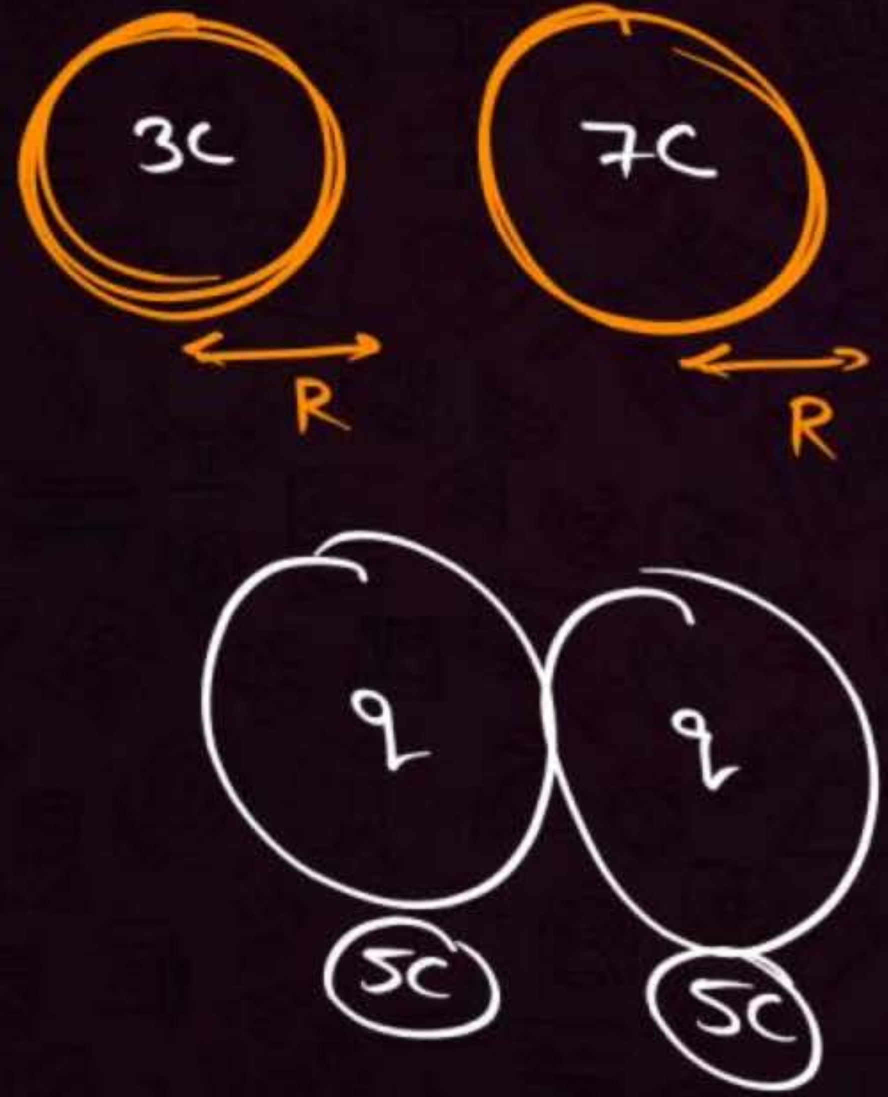



Touch.


Conducting wire

Ek Tera, Ek Mera - If bodies are identical, then charges are equally distributed after conduction.

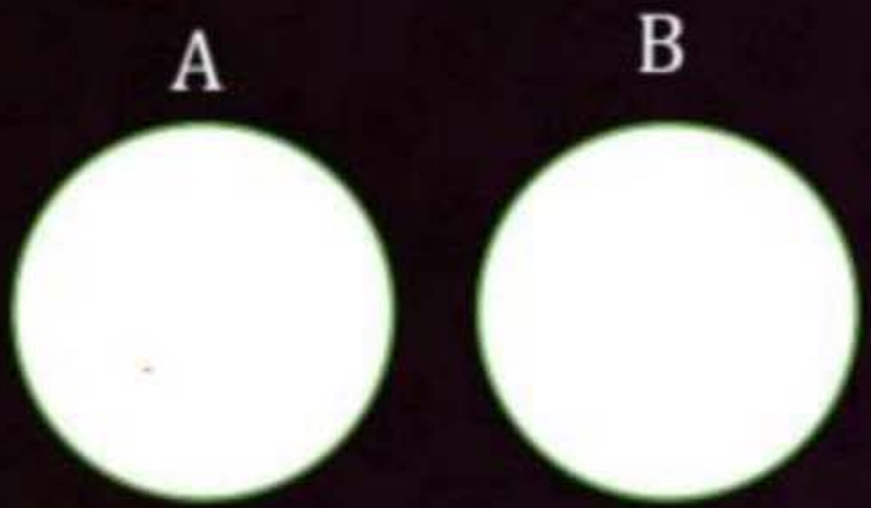
R equal



$$q = \frac{\text{Total charge}}{\text{No. of bodies}} = \frac{3+7}{2} = \frac{10}{2} = 5C$$

QUESTION

Find the charges on the identical bodies after conduction.



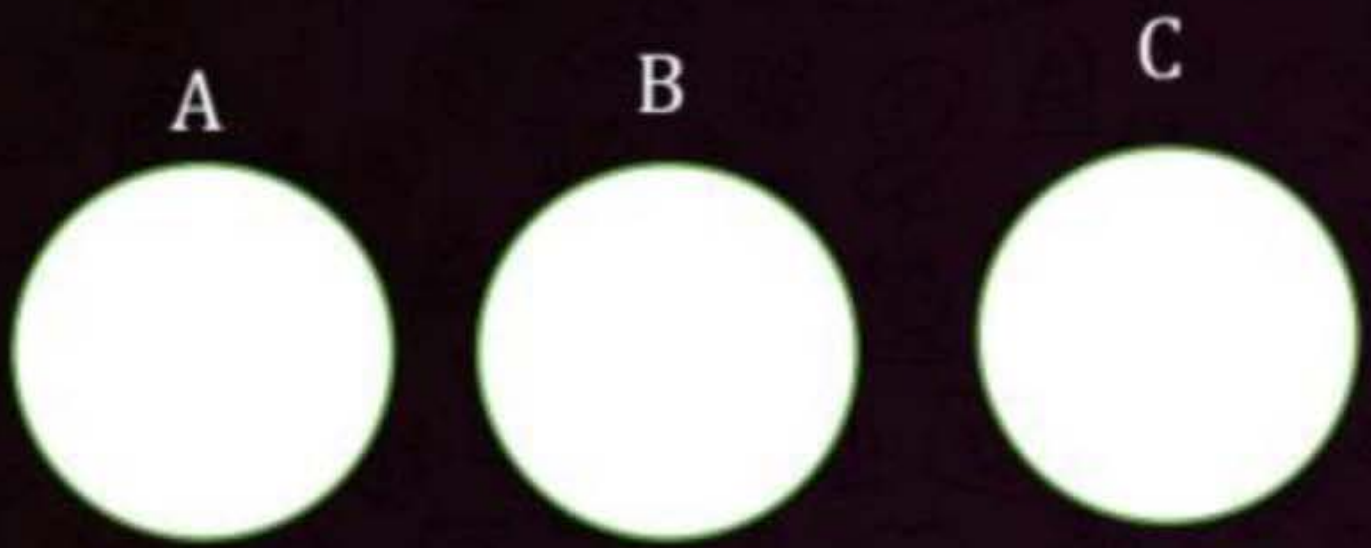
$1.5c$ ✓

$1.5e$ ✗

3C	5C	$\frac{3+5}{2} = 4C$
4C	6 C	$\frac{10}{2} = 5C$
7C	-3C	$\frac{7-3}{2} = \frac{4}{2} = 2c$
5C	-2C	$\frac{5-2}{2} = \frac{3}{2} = 1.5c$

QUESTION

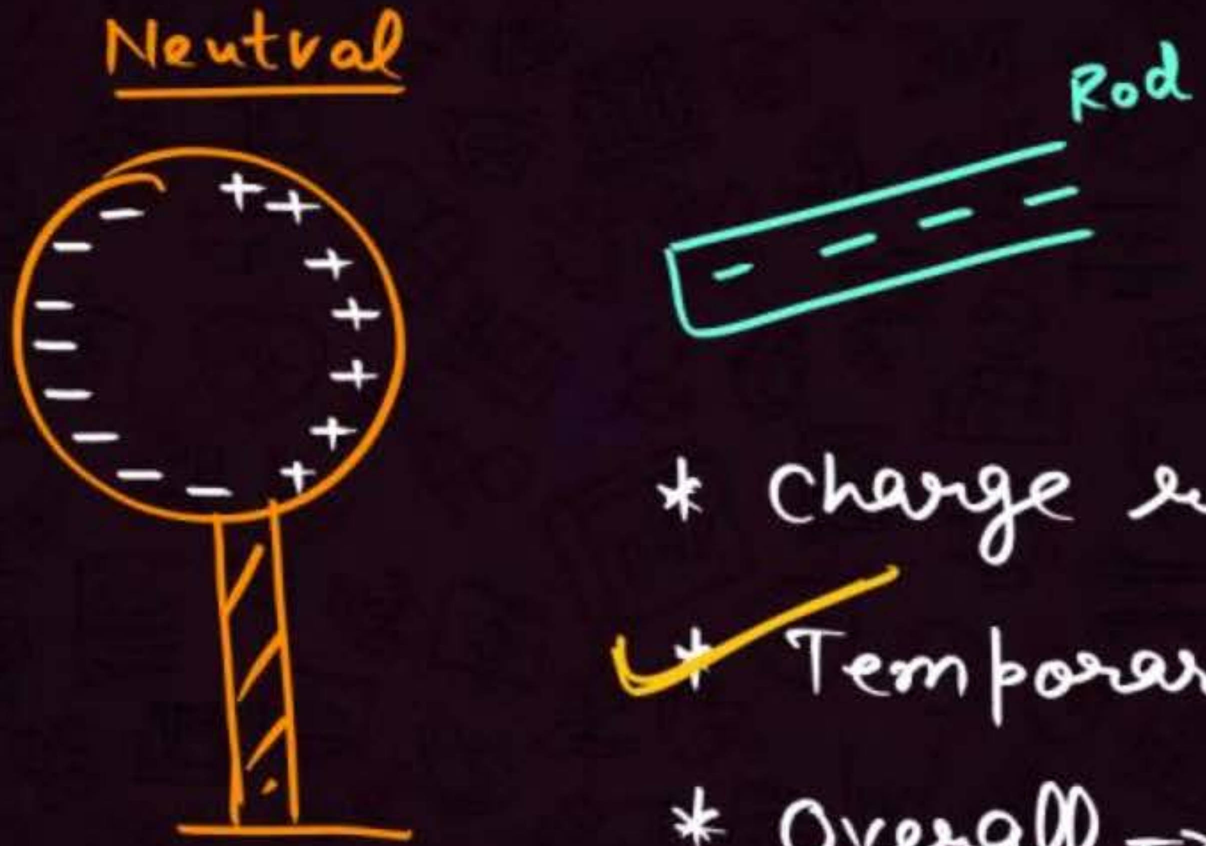
Find the charges on the identical bodies after touching them simultaneously



3C	5C	4C	$\Rightarrow \frac{12}{3} = 4C$
4C	6 C	8C	$\Rightarrow \frac{18}{3} = 6C$
7C	-3C	5C	$\Rightarrow \frac{9}{3} = 3C$

3. By Induction

- Charged body is used to create other charged bodies without touching them.

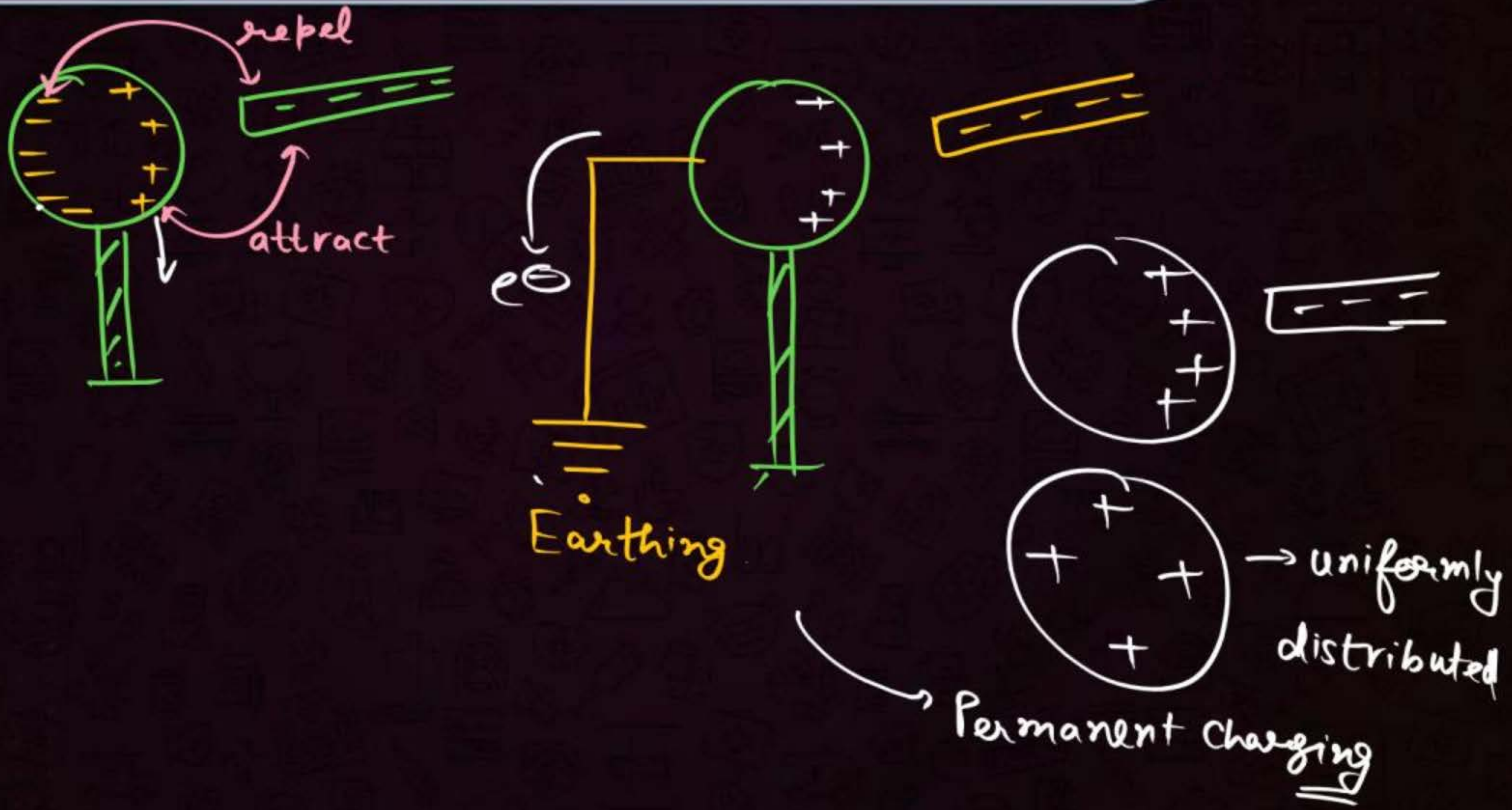


* Charge redistribution.

* Temporary

* Overall ⇒ Neutral (Net $q=0$)

Charging by Induction Explained in Steps



QUESTION

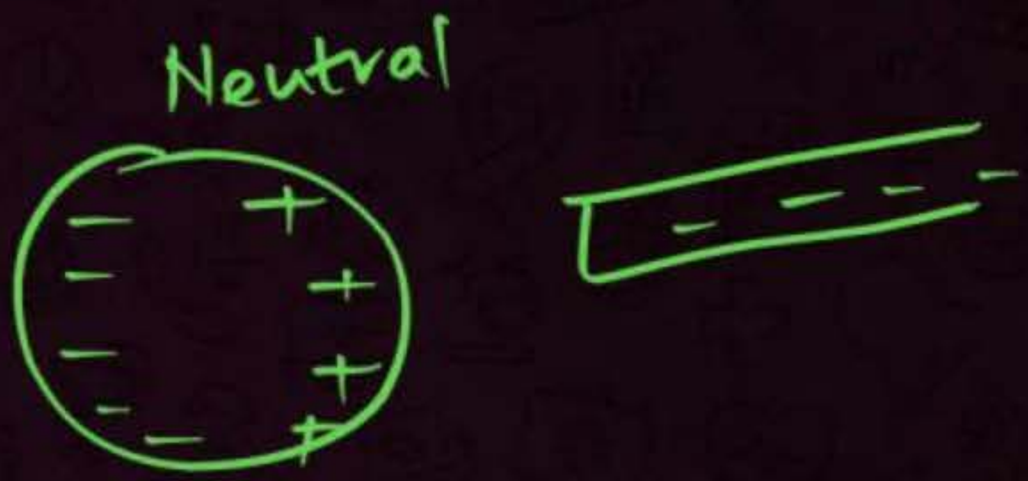
A charged rod is brought near an isolated neutral conducting sphere, then sphere

① Gets positively charged

② Gets negatively charged

[✓ ③ Remains neutral]

④ Can't predict



QUESTION

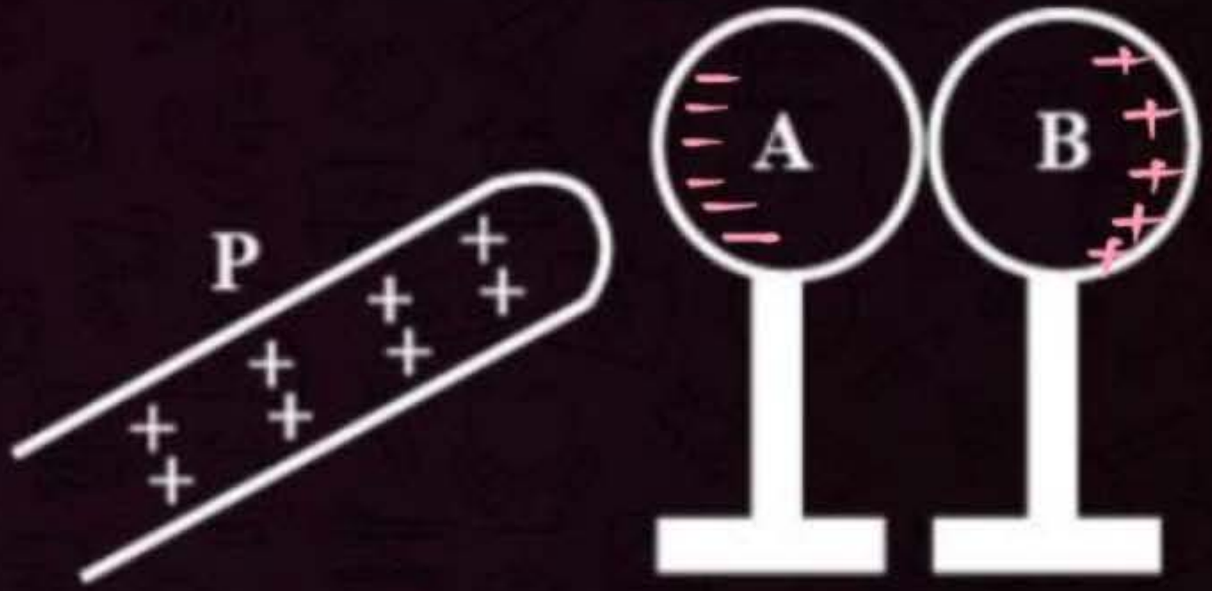
In the given diagram, if rod is placed very near to spheres, then

① Both become negative

② Both become positive

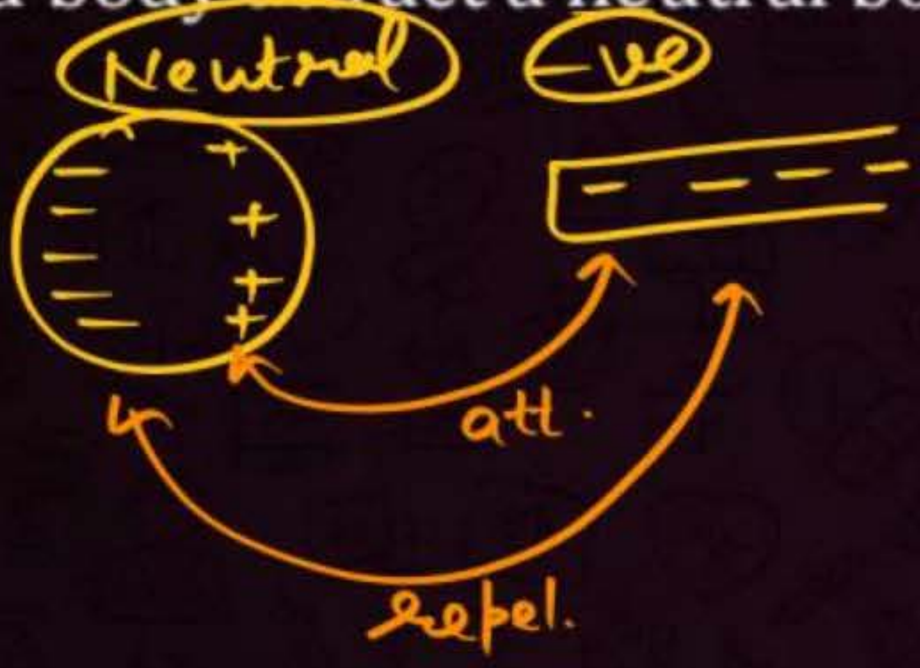
[✓ ③ A is negative, B is positive]

④ A is positive, B is negative



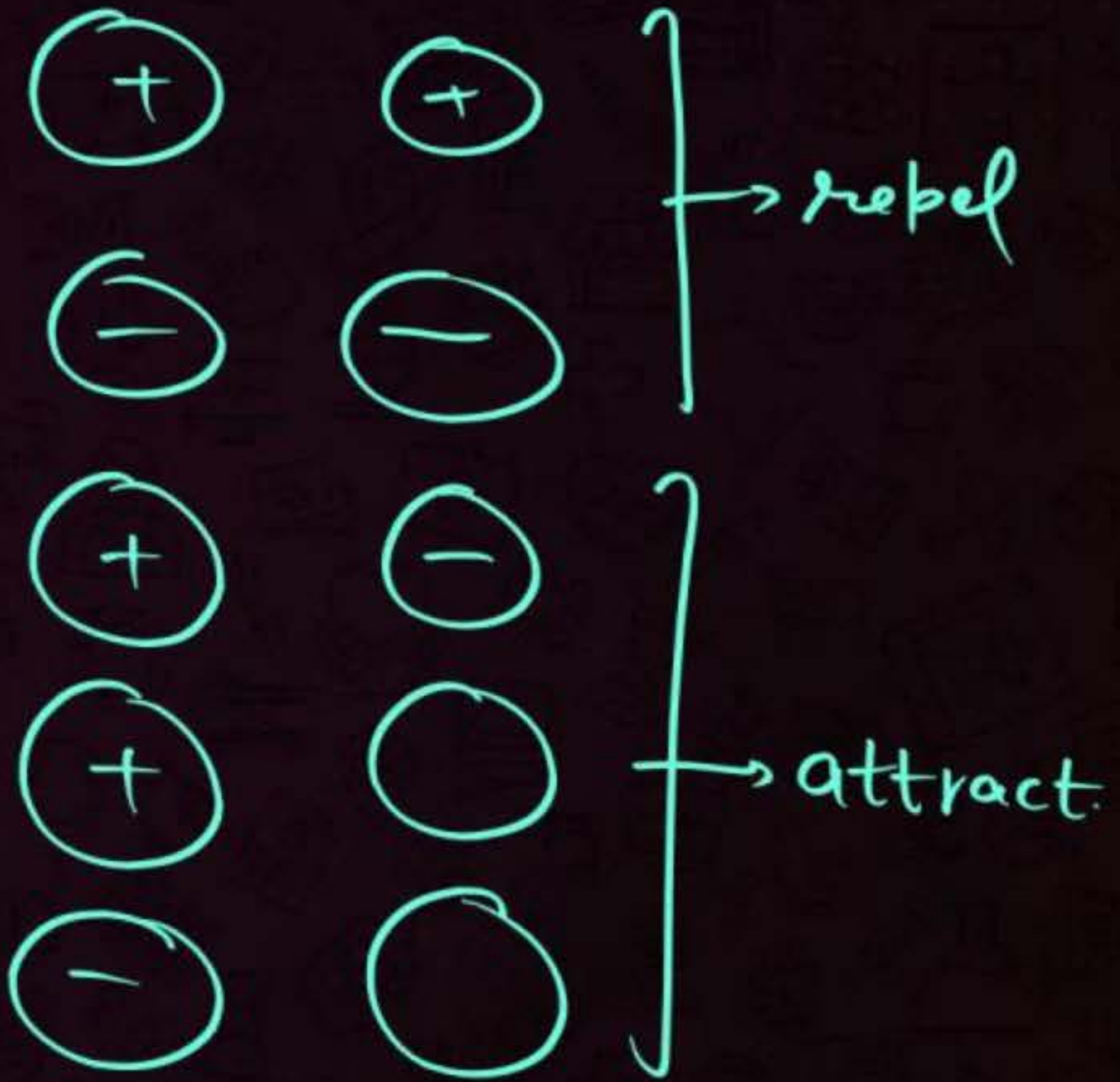
Soch Bhai Soch

Can a charged body attract a neutral body?



att > rep.

Net F => attractive



- Repulsion is sure test of electrification

GOLD LEAF ELECTROSCOPE

(GLE)

Gold → melleable

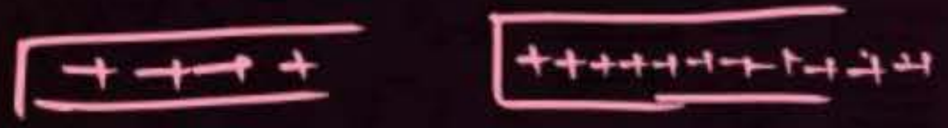
↳ Light weight
conductor

Device used to roughly estimate the charge on the body

$\boxed{\text{Charge} \propto \theta}$

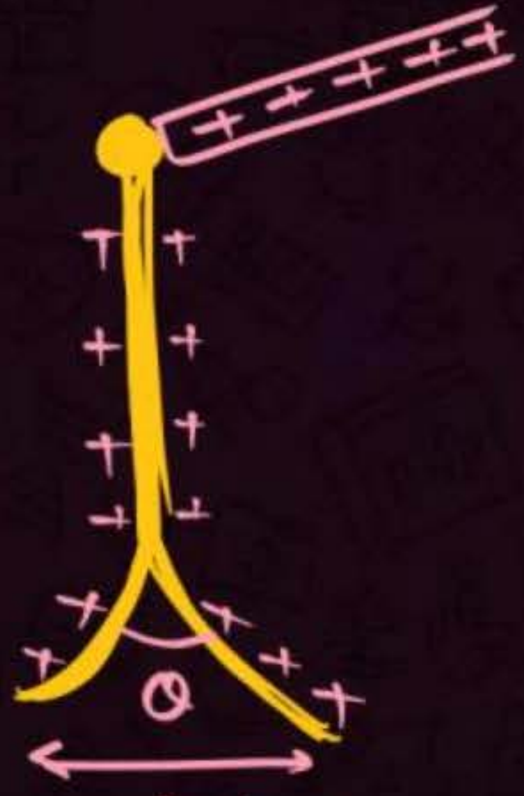
↓

Diverge

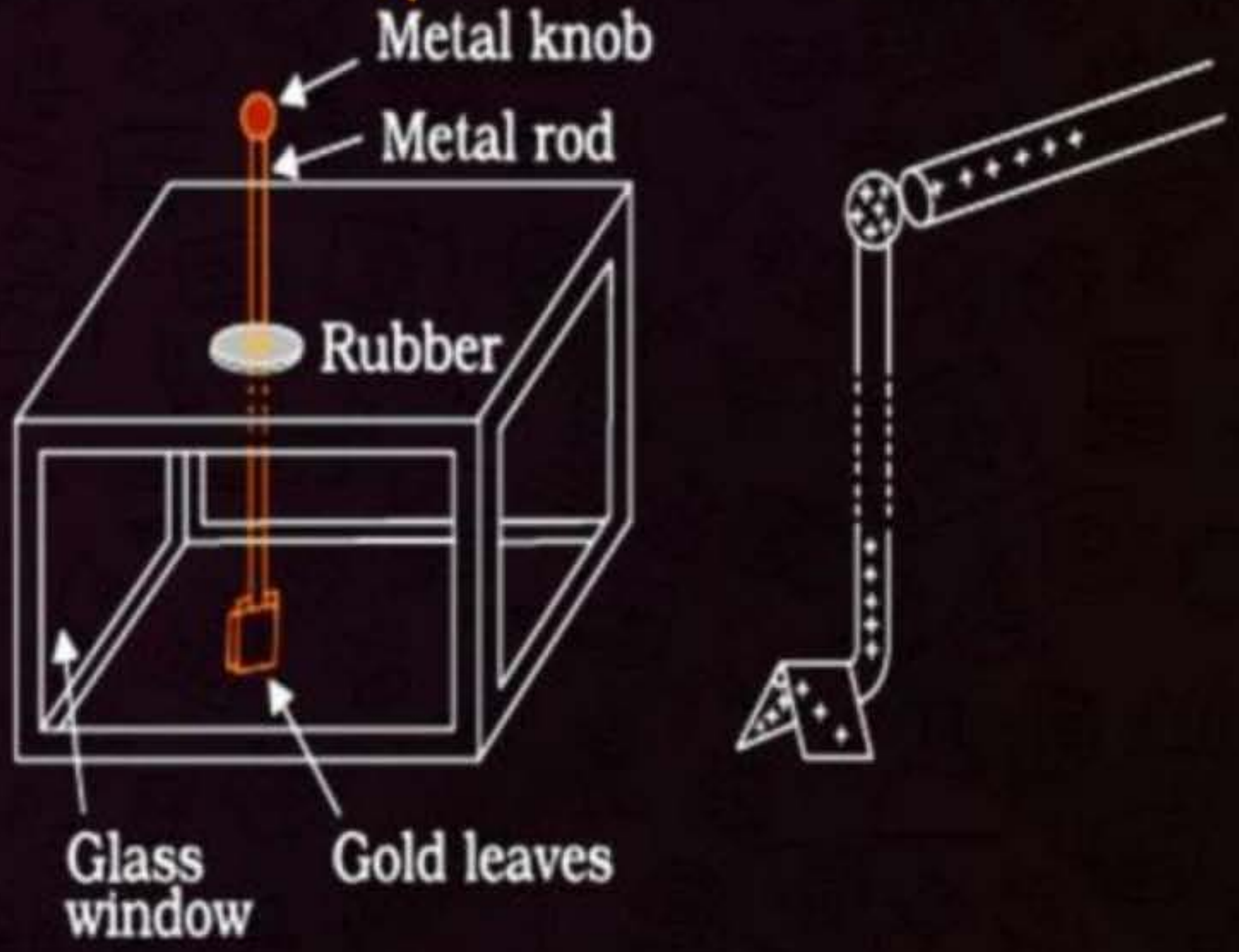


$q_1 < q_2$

$\theta_1 < \theta_2$



repel.



Samajh Aane ki Acting!!!

COULOMB'S LAW

$$\boxed{\underset{N}{F} = k\frac{\overset{C^2}{q_1 q_2}}{\underset{m^2}{r^2}}}$$

$$F \propto q_1 q_2$$

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

k = coulomb's const.

$k = 9\times10^9$ (SI units → $\frac{Nm^2}{C^2}$)

k = 1 (cgs unit)

$$F = \frac{Gm_1m_2}{r^2}$$

Thoda sa change kr deta hu,
Nahi to lgega ki Copy kiya hai

* acts along line joining both charges

Coulomb

Properties of Coulomb (Electrostatic) Force

$+ \; +$, $- \; -$ } $\Rightarrow q_1 q_2 = + > 0$

$+ \; -$] $\Rightarrow q_1 q_2 \Rightarrow - < 0$

1. Attraction and repulsion depends on sign of charges.

Ques If $q_1 q_2 > 0 \Rightarrow$ Repel

Ques If $q_1 q_2 < 0 \Rightarrow$ attract

2. Valid for point charges

$\dot{q_1}$ $\dot{q_2}$

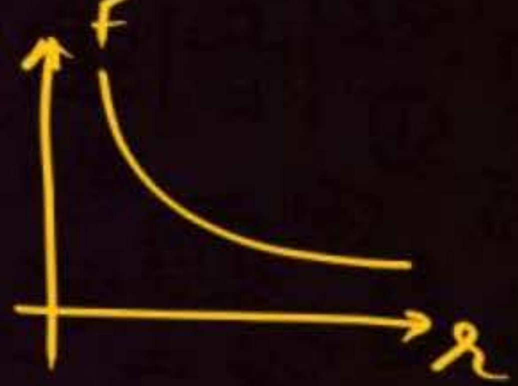
also for spheres

3. Follow Newton's 3rd Law. equal & opposite

4. Both Newton's law of gravitation and Coulomb's law follow inverse square law.

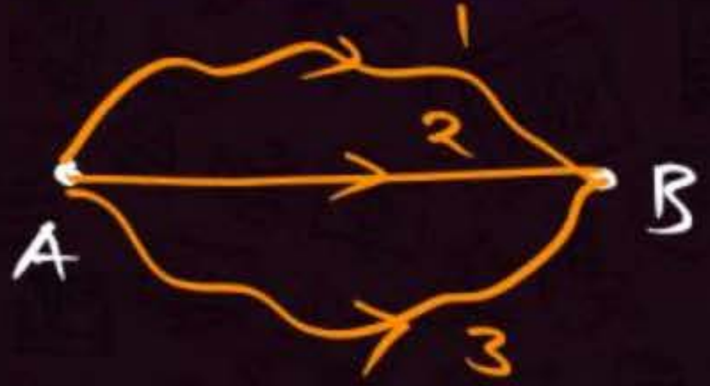
$$\boxed{F \propto \frac{1}{r^2}}$$

• long range force



5. Electrostatic forces are conservative in nature.

* grav. force
* spring force.



$W_1 = W_2 = W_3$

work done

cons.

independent of path

6. Electrostatic forces are much stronger than the gravitational forces.

$F_e >> F_g$

↳ weakest

QUESTION

BPU

Two point charges are separated by a distance d repel each other with a force 8 N. If distance between them is changed to 2d, then force will become:

① 1 N

② 0.5 N

③ 16 N

[✓ ④ 2 N]

$$F = \frac{k q_1 q_2}{d^2} = 8$$

$$F' = \frac{k \times q_1 q_2}{(2d)^2} = \frac{k q_1 q_2}{4 d^2} = \frac{F}{4} = \frac{8}{4} = 2$$

$$\frac{8}{2^2} = \boxed{2\ N}$$

* $F = 27\,N \Rightarrow d \rightarrow \boxed{3d} \Rightarrow F' = ?$

$$F' = \frac{27}{3^2} = \frac{27}{9} = 3N$$

$F = 128\,N \Rightarrow$ distance ↓ quadrupled $\Rightarrow F' = ?$

4 times

$$F' = \frac{128}{4^2} = \frac{128}{16} = \boxed{8\,N}$$

QUESTION

BPU

Two point charges exert a force F on each other. If distance between them is made 4 times and both charges are doubled, then new force is

① F

② F/4 ✓ (2×)

③ F/16

④ F/8

$$F = \frac{kq_1q_2}{r^2}$$

$$F' = \frac{k \times 2q_1 \times 2q_2}{(4r)^2} = \frac{\cancel{4}\, kq_1q_2}{\underset{4}{\cancel{16}}\, r^2} = \frac{F}{4}$$

$$\boxed{\frac{2\times2}{4^2} = \frac{4}{16} = \frac{1}{4}}$$

QUESTION

Two charges 10 C and 5 C are placed 20 cm apart. The ratio of Coulomb's force experienced by them is:

① 2 : 5

② [✓ 1 : 1]

③ $\sqrt{3} = \sqrt{7}$

④ None of these

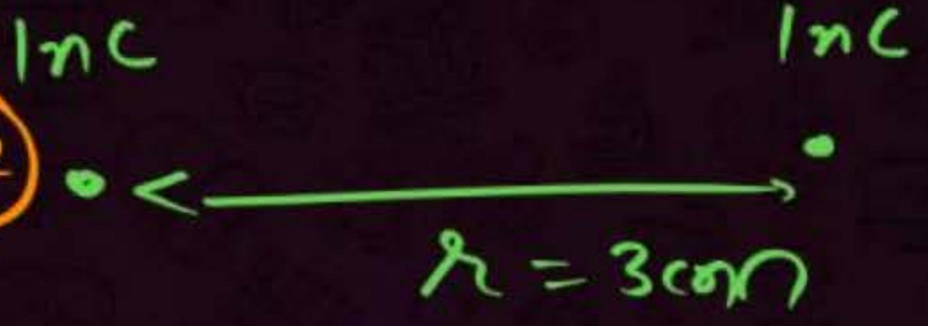
$\frac{F}{F} = \frac{1}{1}$

QUESTION

Two charges of 1 nC are placed at a distance of 3 cm from each other in vacuum. Find electrostatic force between them.

1. 10^5 dyne
2. 10^{-5} dyne
3. 10^{-3} dyne
4. [✓ 1 dyne]

$\bigstar$ $\boxed{1\,gf = 980\,dyne}$



$r = 3\,cm$
$= 3\times10^{-2}\,m$

$\bigstar$ $\boxed{1\,N = 10^5\,dyne}$

$$F = \frac{9\times\cancel{10^{9}}\times\cancel{10^{-9}}\times10^{-9}}{(3\times10^{-2})^2}$$

$$= \frac{\cancel{9}\times\cancel{10^{-9}}}{\cancel{9}\times\cancel{10^{-4}}} = 10^{-5}\,N = 10^{-5}\times10^{5}$$

$$= 1\,dyne$$

QUESTION

Two identical conducting spheres have charges 6 C and 2 C respectively placed at certain distance have force F between them. If they are touched with each other and then placed at same distance, then force becomes

① F

② 2F/3

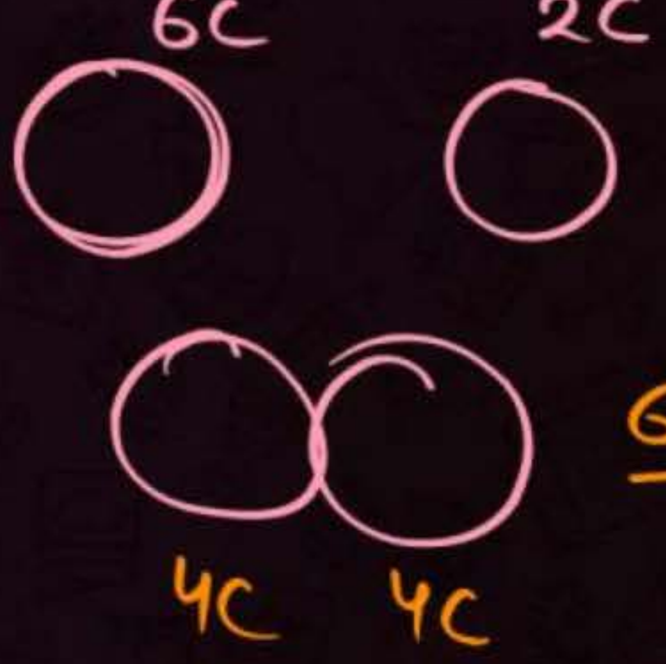
[✓ ③ 4F/3]

④ 8F/3

$$F = \frac{k \times 6 \times 2}{r^2} = \frac{12k}{r^2}$$

$$F' = \frac{k \times 4 \times 4}{r^2} = \frac{16}{r^2}$$

$$\frac{F'}{F} = \frac{16}{12} = \frac{4}{3} \Rightarrow F' = \frac{4F}{3}$$



$$\frac{6+2}{2} = 4.$$

QUESTION

$$\frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$$

Two point charges A and B, having charges +Q and –Q respectively, are placed at certain distance apart and force acting between them is F. If 25% charge of A is transferred to B, then force between the charges becomes: **(NEET 2019)**

$$\frac{25}{100} = \frac{1}{4}$$

① 16 F/9

② 4 F/3

③ F

[✓ ④ 9 F/16]

$$+Q \xleftrightarrow[r]{\qquad} -Q$$

$$F = \frac{k \times Q \times Q}{r^2} = \frac{kQ^2}{r^2}$$

$$\underline{\underline{A}} \quad Q - \frac{Q}{4} = \frac{3Q}{4}$$

$$\underline{\underline{B}} \quad -Q + \frac{Q}{4} = -\frac{3Q}{4}$$

$$A \xrightarrow{Q/4} B$$

$$F' = \frac{k \times \frac{3Q}{4} \times \frac{3Q}{4}}{r^2} = \boxed{\frac{9}{16}} \frac{kQ^2}{r^2} = \frac{9F}{16}$$

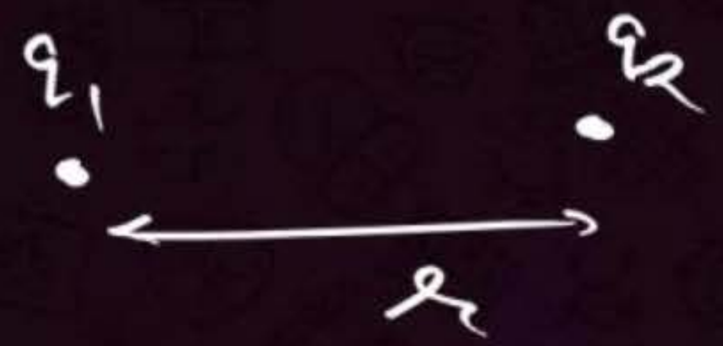
QUESTION

(Famous Type)

A $\boxed{10\ \mu C}$ charge is divided into two parts and placed at 1 cm distance so that the repulsive force between them is maximum. The charges of the two parts are:

[JEE Mains 13 April, 2023]

1. 9 μC, 1 μC
[✓ 2.] 5 μC, 5μC
3. 7 μC, 3 μC
4. 8 μC, 2 μC



$q_1 + q_2 = 10$

$9 \times 1 = 9$

$8 \times 2 = 16$

$7 \times 3 = 21$

$6 \times 4 = 24$

$5 \times 5 = \boxed{25}$

$$F = k\frac{\boxed{q_1 q_2}}{r^2} \rightarrow \max^m$$

$\downarrow$ $\max^m$

TBS $q_1 + q_2 = \text{const.}$

$F \rightarrow \max^m$

$\boxed{q_1 = q_2}$

$q_1 = 10$

$q_2 = 0$

$F_{min} = 0$

PERMITTIVITY

$\epsilon \Rightarrow$ medium

$$k = \frac{1}{4\pi\epsilon_0}$$

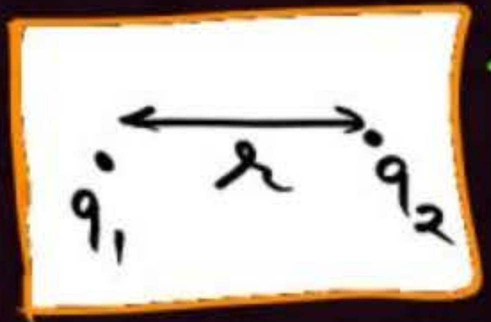
$$\downarrow$$

$$\frac{Nm^2}{C^2}$$

$\epsilon_0 \Rightarrow$ permittivity of vaccum (air)

$$\epsilon_0 \Rightarrow 8.85 \times 10^{-12} \boxed{\frac{C^2}{Nm^2}} \longrightarrow \text{NEET PYQ}$$

$$F = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2}$$



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

$$F' = \frac{1}{4\pi\epsilon_0 \epsilon_r} \times \frac{q_1 q_2}{r^2}$$

$$\epsilon_r = K = \frac{\epsilon}{\epsilon_0}$$

$$\epsilon = \epsilon_0 \epsilon_r.$$

K → dielec. const.

$$\boxed{F' = \frac{F}{\epsilon_r} = \frac{F}{K}}$$

decreases

$K = 1$ (vaccum)

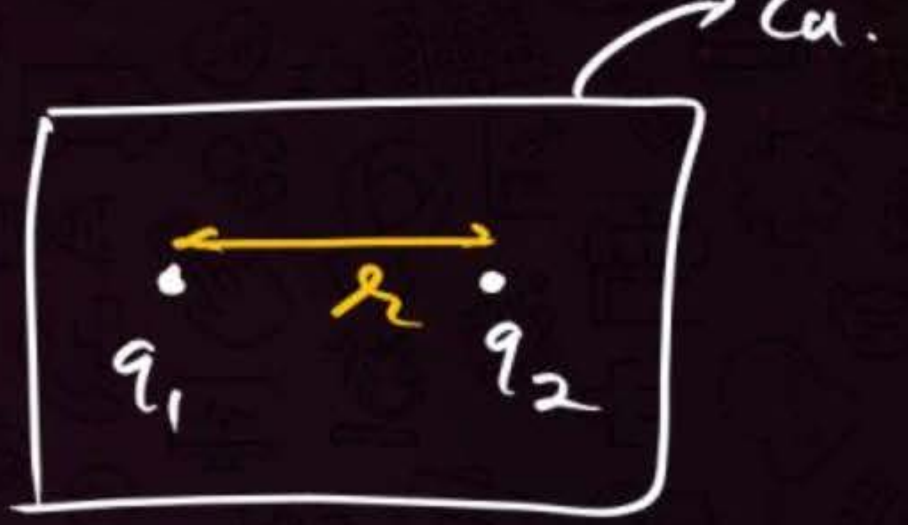
$K \simeq 1$ (air)

$K > 1$ (medium)

$\boxed{K \to \infty}$ (conductors)

eg :- <u>metal</u>

$\boxed{F = 0}$ ☆



$$F' = \frac{F}{K} = \frac{F}{\infty} \Rightarrow \boxed{\text{zero}}$$

QUESTION

A force of 4N is acting between two charges in air. If the space between them is completely filled with glass ($\varepsilon_r = 8$), then the new force will be

① 2N

② 5N

③ 0.2N

④ [✓ 0.5N]

$$F' = \frac{F}{\epsilon_r} = \frac{4}{8} = \frac{1}{2} = 0.5\,N$$

QUESTION

Two charges placed in air repel each other by a force of 10^{-4} N. When oil is introduced between the charges, the force on the charge becomes 2.5×10^{-5} N. The dielectric constant of oil is:

① 2

② [✓ 4]

③ 2.5

④ 0.25

$$F = 10^{-4}$$

$$F' = 2.5 \times 10^{-5}$$

$$\boxed{K = \epsilon_r} \longrightarrow \text{No units}$$

$$\epsilon_r = \frac{\epsilon}{\epsilon_0}$$

$$F' = \frac{F}{K} \Rightarrow K = \frac{F}{F'} = \frac{\cancel{10^{-4}}}{2.5 \times \cancel{10^{-5}}} = \frac{10}{2.5}$$

$$10^{-1}$$

$$= 4$$

QUESTION

Assertion (A): Force between two charges decreases when air separating the charges is replaced by water.

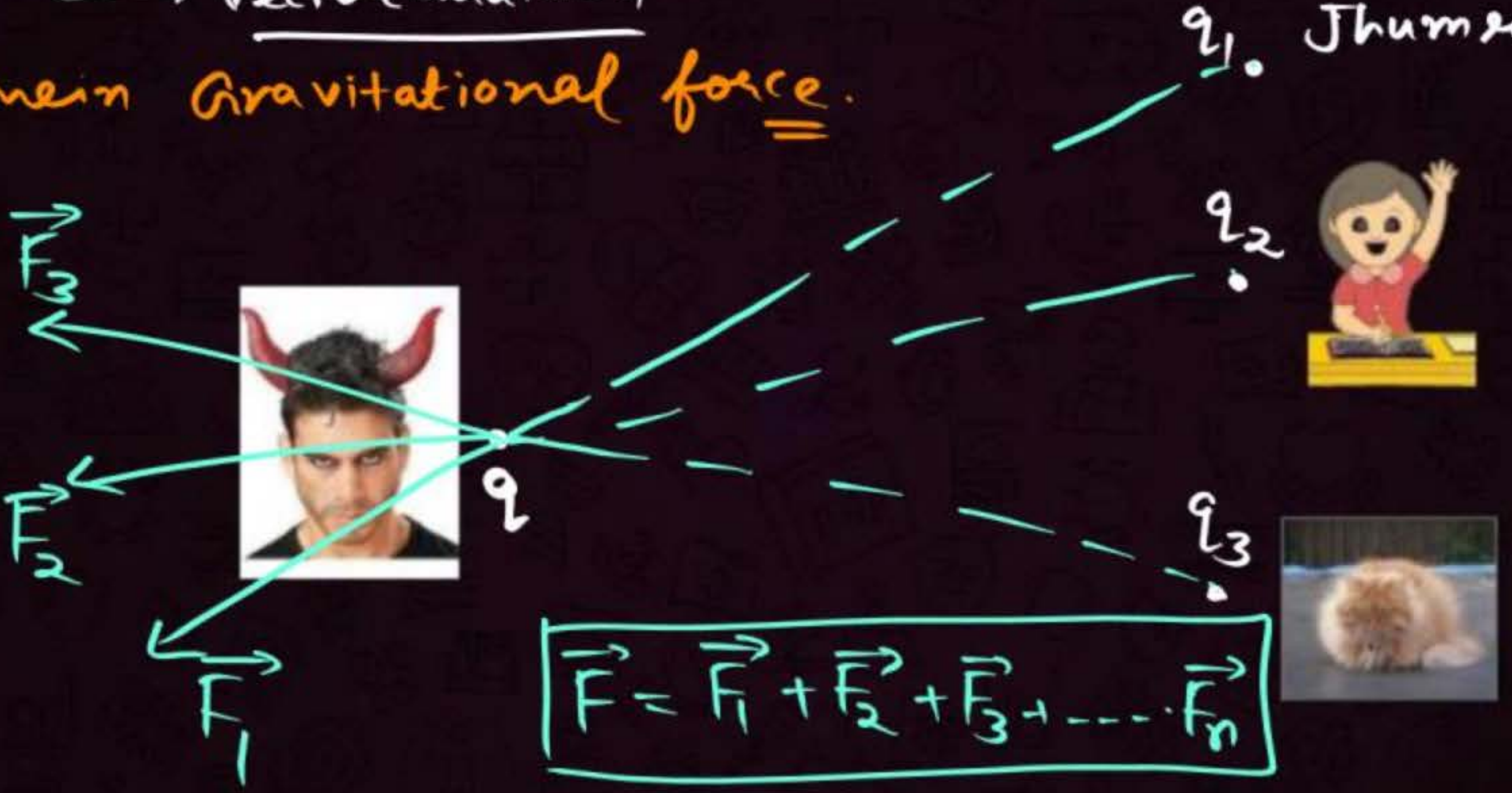
Reason (R): Medium intervening the charges has no effect on force.

1. Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A)
2. Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A)
3. [✓ Assertion (A) is True, Reason (R) is False.]
4. Assertion (A) is False, Reason (R) is True.

SUPERPOSITION PRINCIPLE (Hmara Dholu, Sabka Pyaara)

→ vector addition

Samein Gravitational force.



$$\boxed{\vec{F} = \vec{F_1} + \vec{F_2} + \vec{F_3} + \dots \vec{F_n}}$$

The electrostatic force between two charge particles is independent of the presence of third charge.

Ques

↓

Force on middle charge

$$F = \frac{k \times q \times q}{r^2} = \frac{kq^2}{r^2}$$

$$F_1 = F_2 = F$$

$$F_{net} = F - F = 0$$

Ques

↓

Force on right charge.

$$\frac{kq}{r^2} = F \text{ (Use)}$$

A) 2F   B) F   [✓ C) 1.25 F]   D) Humein Kya Pta!!!

$$F_2 = \frac{kq^2}{r^2} = F$$

$$F_1 = \frac{kq^2}{(2r)^2} = \frac{kq^2}{4r^2} = \frac{F}{4}$$

$$F + \frac{F}{4}$$

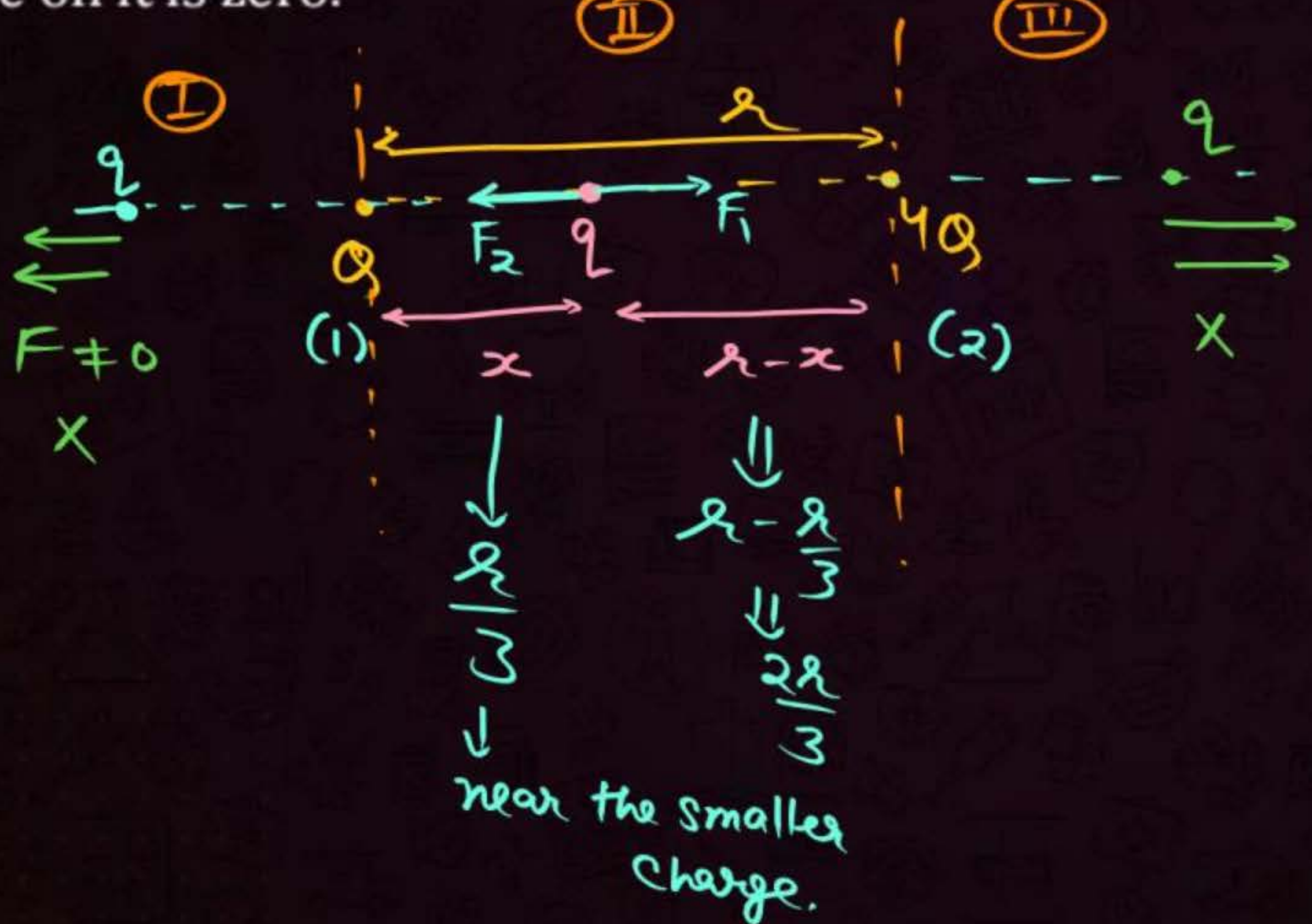
$$= F + 0.25F$$

$$= 1.25F.$$

QUESTION

(Famous type)

Two charges Q and 4Q are shown in figure. Find position of 3rd charge *q* so that net force on it is zero.



$F_{net} = 0 \longrightarrow \underline{\underline{eqb^m}}$

$F_1 = F_2$

$$\frac{\cancel{K}\cancel{Q}\cancel{q}}{x^2} = \frac{\cancel{K} \times 4\cancel{Q} \times \cancel{q}}{(r-x)^2}$$

$$\frac{1}{x^2} = \frac{4}{(r-x)^2}$$

$$\frac{1}{x} = \frac{2}{r-x}$$

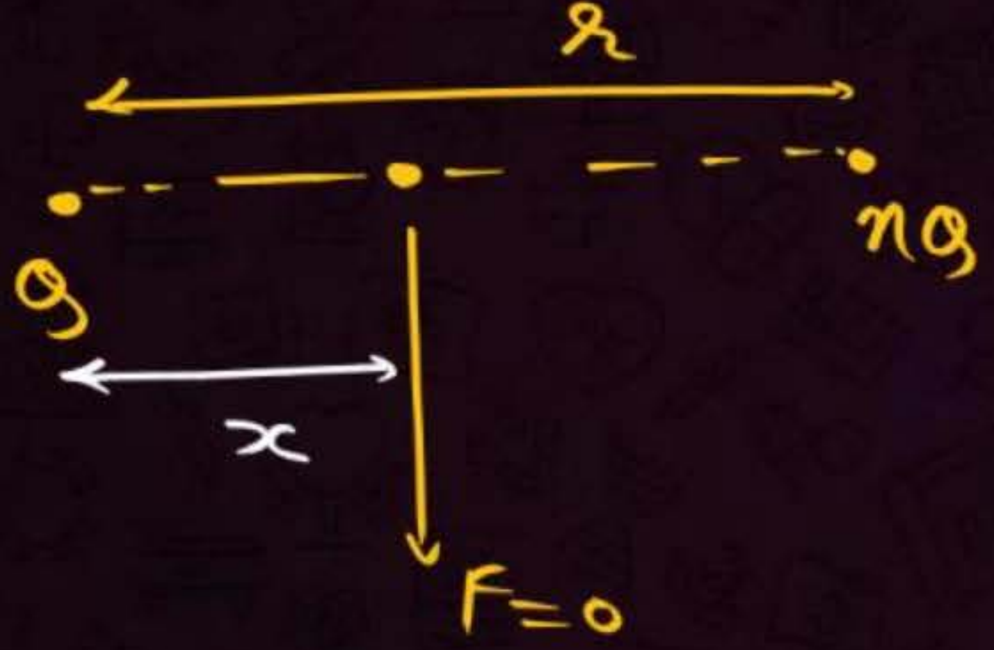
$r - x = 2x$

$r = 3x \Rightarrow \boxed{x = r/3}$

Concept for Similar Charges

⇓

Both +ve or Both -ve



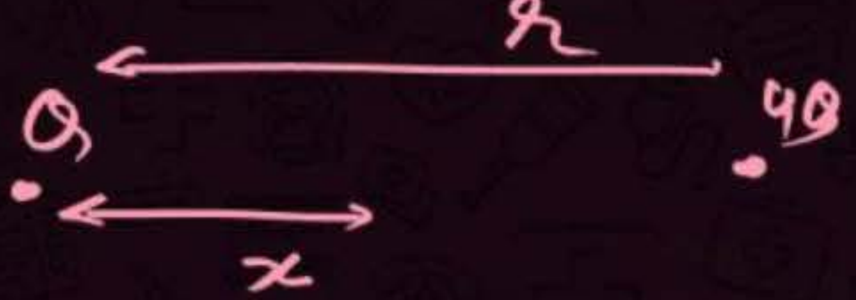
$$\boxed{x = \frac{r}{\sqrt{n}+1}}$$

→ from chhota q.

$$\boxed{n = \frac{\text{Bada Charge}}{\text{Chhota Charge}}}$$

BPD

Ques



$n = \frac{4Q}{Q} = 4$

$x = \frac{r}{\sqrt{4}+1} = \frac{r}{2+1} = \boxed{\frac{r}{3}}$

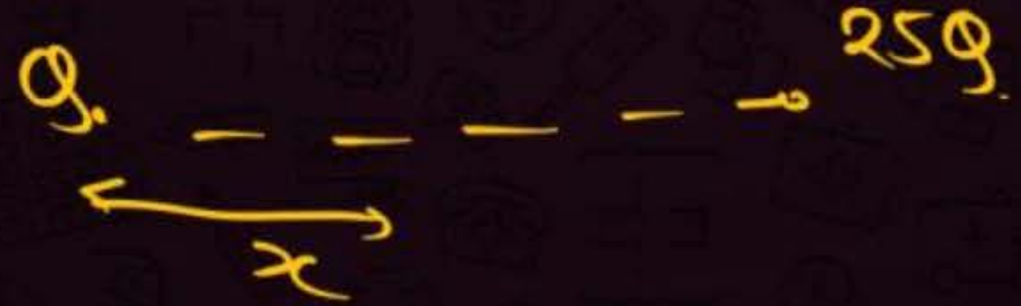
Ques

$x = \frac{r}{\sqrt{9}+1} = \frac{r}{3+1} = \boxed{\frac{r}{4}}$

Ques

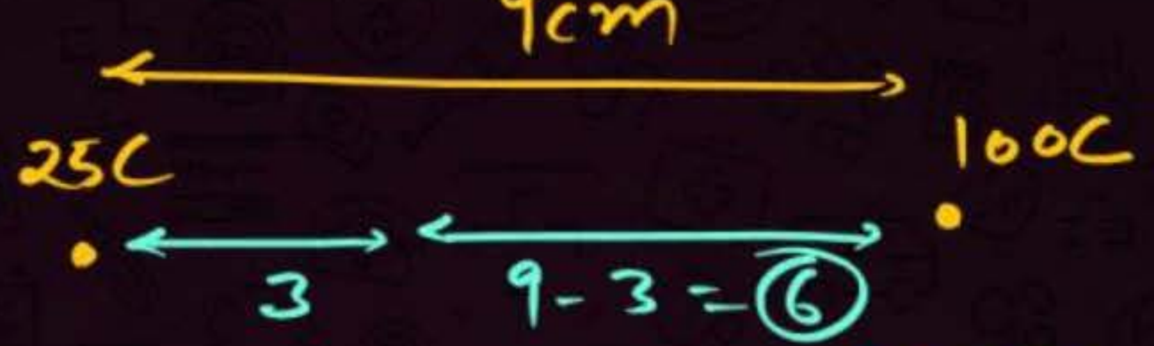
$x = \frac{r}{\sqrt{16}+1} = \frac{r}{4+1} = \boxed{\frac{r}{5}}$

Ques



$x = \frac{r}{\sqrt{25}+1} = \frac{r}{5+1} = \boxed{\frac{r}{6}}$

Ques



Find distance from 100C where $F_{net} = 0$

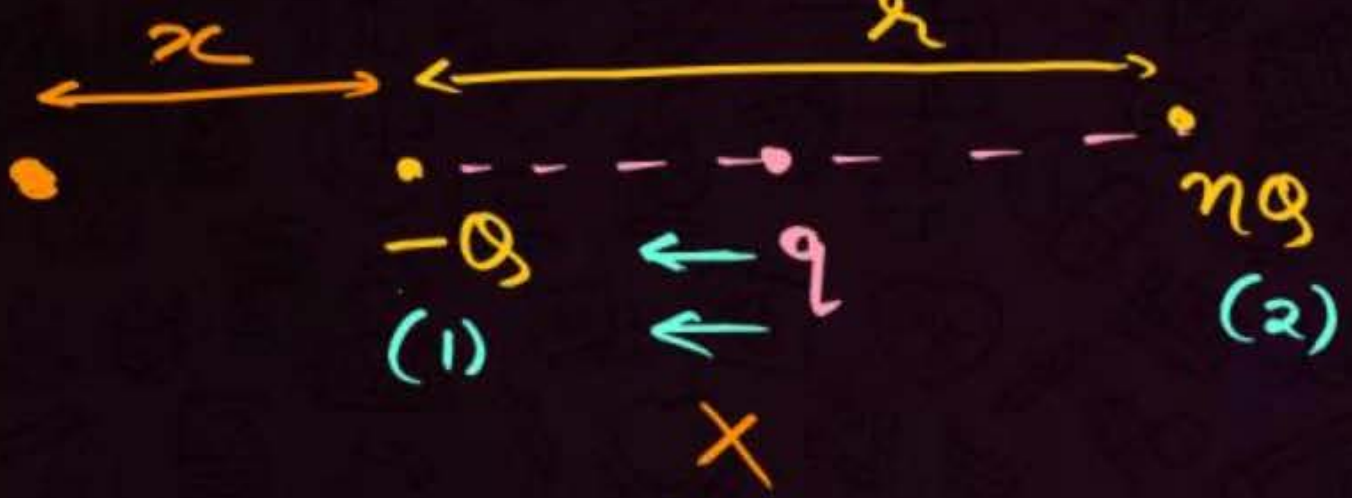
$n = \frac{100}{25} = 4$ $\quad x = \frac{r}{\sqrt{n}+1} = \frac{9}{\sqrt{4}+1} = \frac{9}{2+1} = \frac{9}{3} = 3$ Ans ×

$\boxed{6\text{cm}}$ Ans.

Concept for Opposite Charges

⇓

+ & −



$$\boxed{x = \frac{r}{\sqrt{n}-1}}$$

↓

from chhota q.

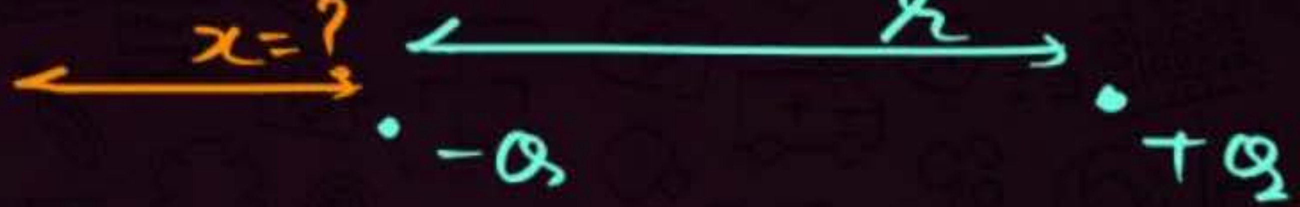
ques

$\boxed{x = r}$

↳ $x = \frac{r}{\sqrt{4}-1} = \frac{r}{2-1} = \boxed{r}$

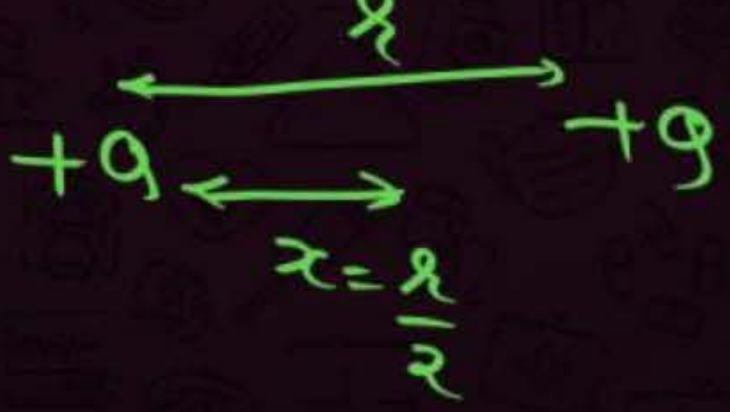
$n = \frac{4Q}{Q} = 4$

Ques



A) 0 B) r C) 2r [✓ D) Doesn't exist.]

$$n = \frac{Q}{Q} = 1 \qquad x = \frac{r}{\sqrt{n} - 1} = \frac{r}{\sqrt{1} - 1} = \frac{r}{0} \Rightarrow \boxed{\infty}$$



$$x = \frac{r}{\sqrt{1} + 1} = \frac{r}{2}$$


Hey Maa..Mata Ji !!

QUESTION

Two particles *A* and *B* having charges 20 μC and –5 μC respectively are held fixed with a separation of 5 cm. At what position a third charged particle should be placed so that it does not experience a net electric force ?

(JEE Main 2021)

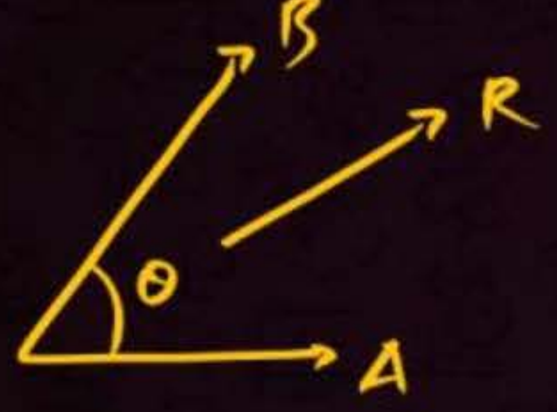
Chhota

1. ✓ At 5 cm from –5 μC on the right side
2. At 5 cm from 20 μC on the left side of system
3. At 1.25 cm from a –5 μC between two charges
4. At midpoint between two charges

$$x = \frac{r}{\sqrt{4}-1} = \frac{r}{2-1} = r = \boxed{5\,cm}$$

No need

Vector Use Hone vala hai (Bhai Krvaega)



$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

If $A = B$ (magnitude equal)

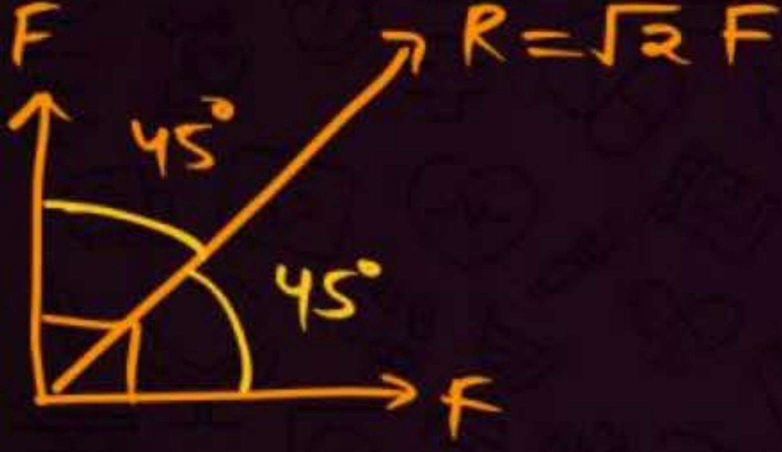
$$\boxed{R = 2A\cos\left(\frac{\theta}{2}\right)}$$

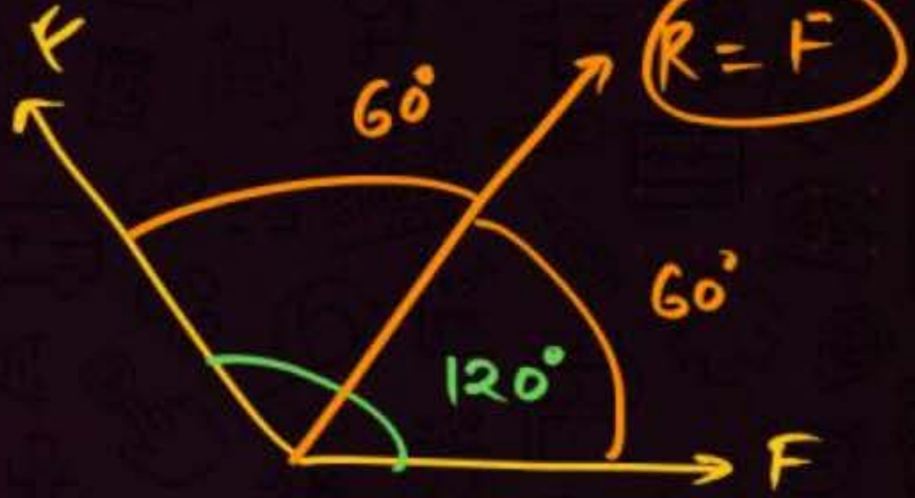
$\theta = 60^\circ$ → $R = \sqrt{3}A$

$\theta = 90^\circ$ → $R = \sqrt{2}A$

$\theta = 120^\circ$ → $R = A$

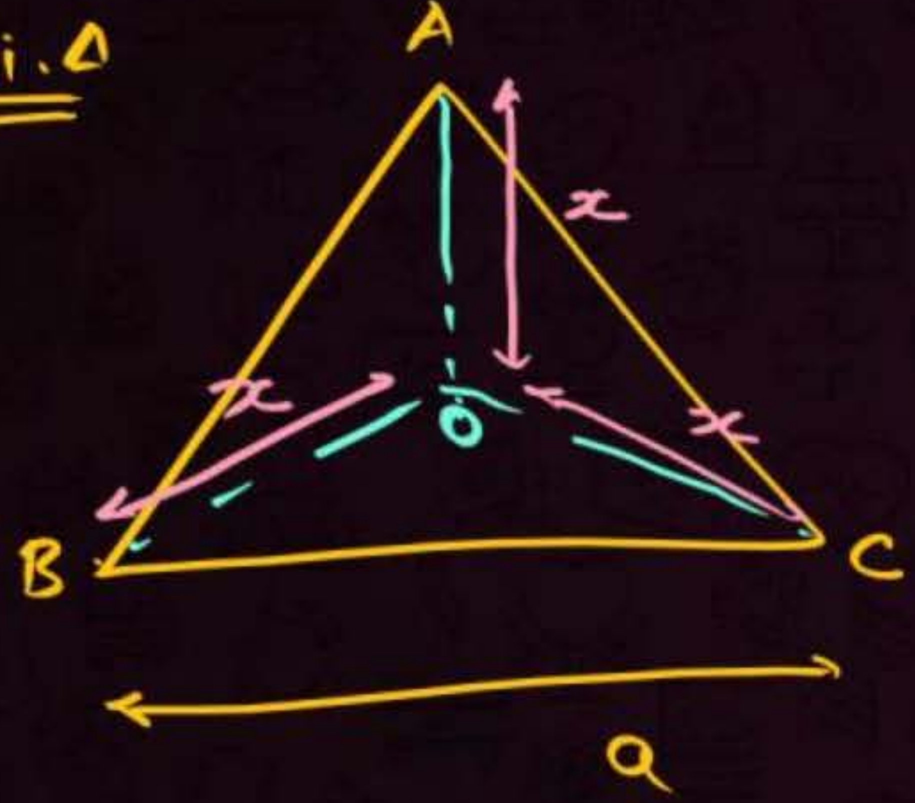

F
30°
$R = \sqrt{3} F$ ✓
60°
30°
F


F
$R = \sqrt{2} F$
45°
45°
F


F
$R = F$
60°
60°
120°
F

TBS Values to Learn

Equi.Δ

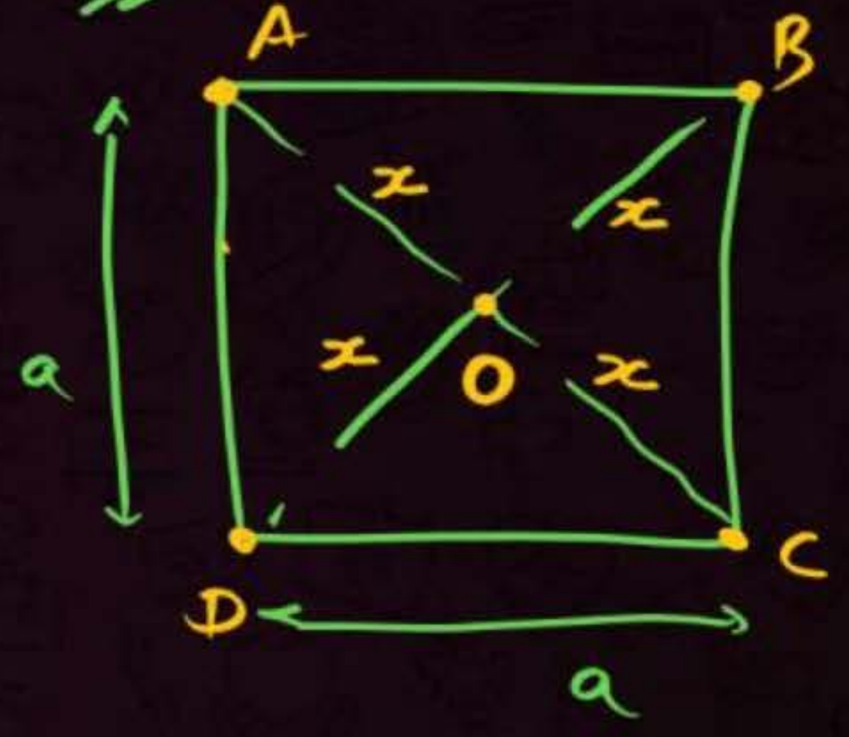


O → centroid

$$\boxed{x = \frac{a}{\sqrt{3}}}$$

TBS

Square

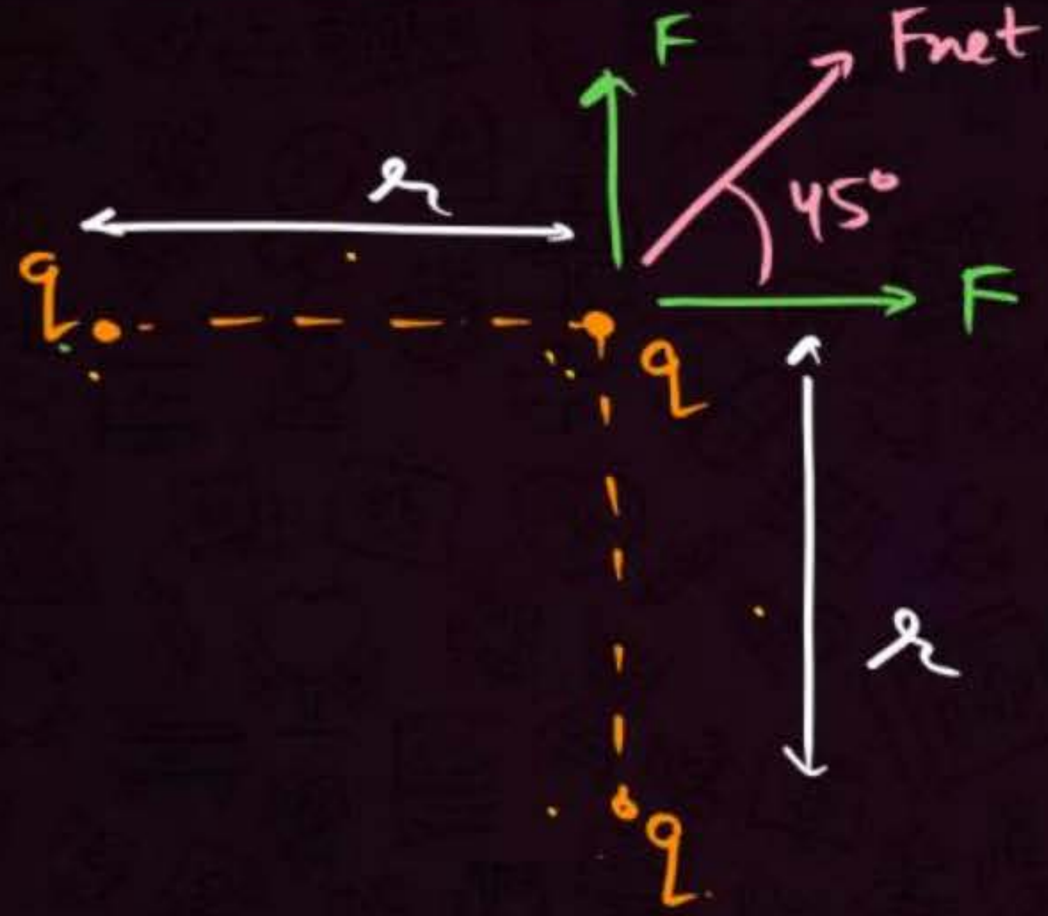


$$\text{Diagonal} = \boxed{\sqrt{2}\,a}$$

$$x = \frac{\text{Diagonal}}{2} = \frac{\sqrt{2}\,a}{2} = \frac{\cancel{\sqrt{2}}\,a}{\sqrt{2} \times \cancel{\sqrt{2}}}$$

$$\boxed{x = \frac{a}{\sqrt{2}}}$$

Application of super-position principle in 2-D



$$F = \frac{kq^2}{r^2}$$

$$F_{net} = \sqrt{2}\,F = \sqrt{2}\,\frac{kq^2}{r^2}$$

QUESTION

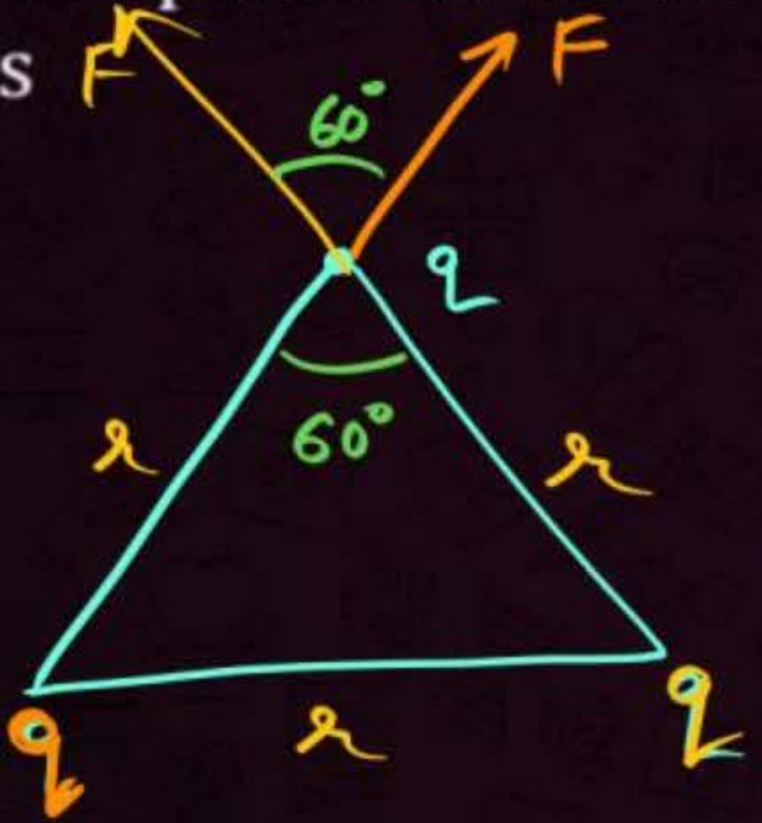
Three equal charges are placed at the vertices of an equilateral triangle. Find net force on any of the charges

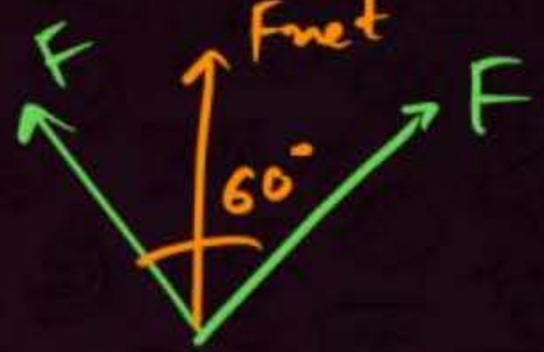
A) $\sqrt{2}\,\frac{kq^2}{r^2}$

B) $\sqrt{3}\,\frac{kq^2}{r^2}$

C) $\frac{kq^2}{r^2}$

D) None.

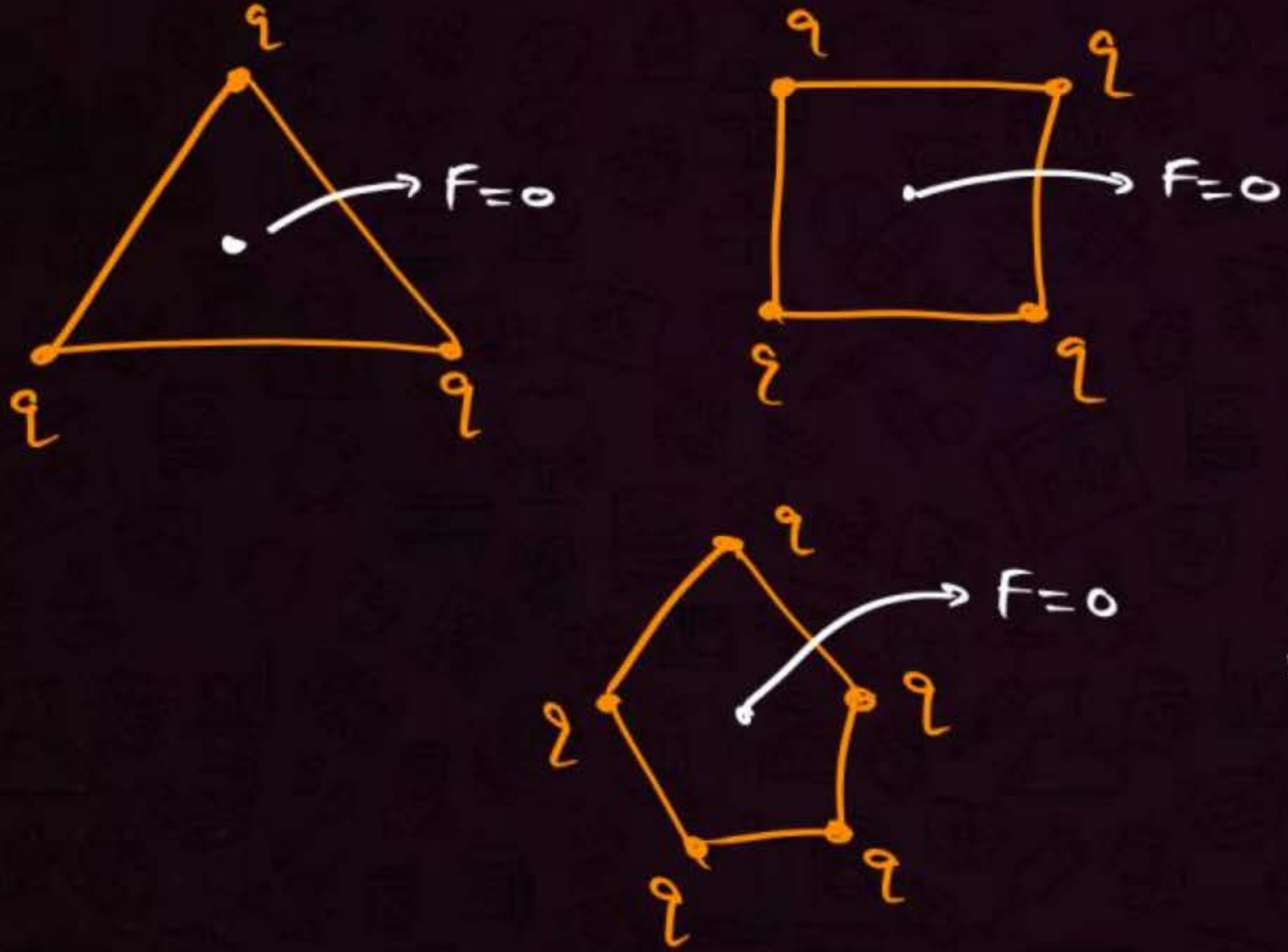




$$F_{net} = \sqrt{3}\,F = \sqrt{3}\,\frac{kq^2}{r^2}$$

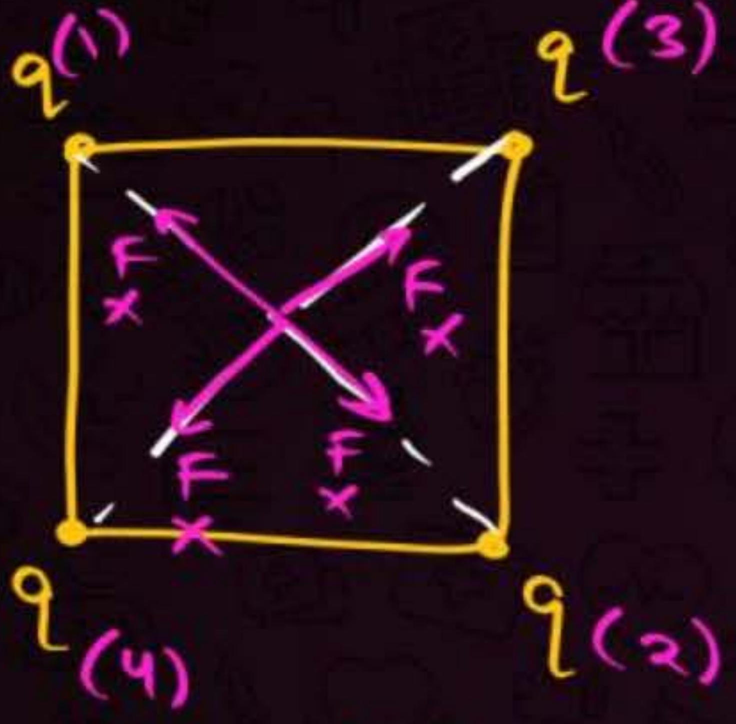
Charge at the center of a regular polygon (Charo Taraf Se Hamla)

→ side equal.

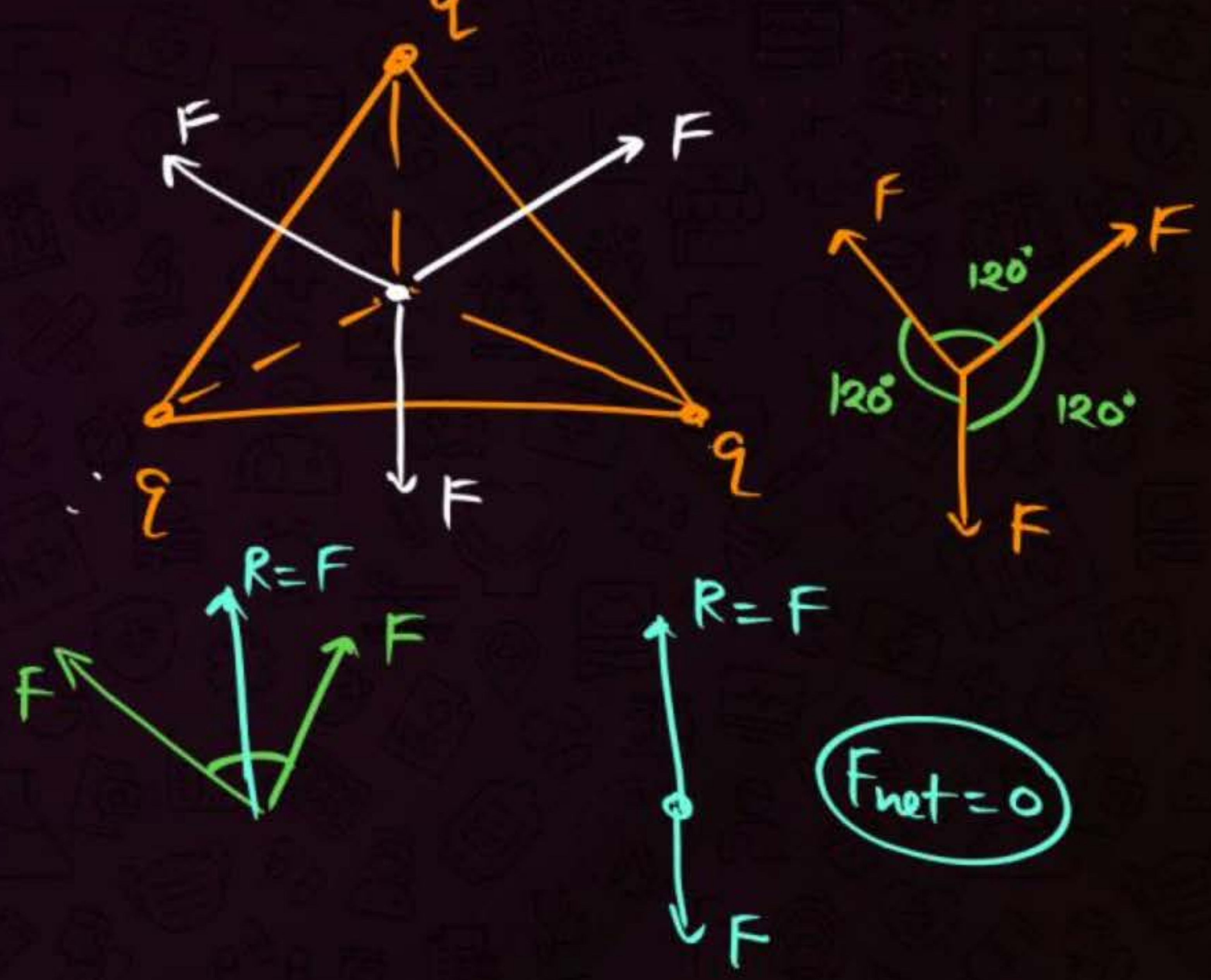


* each vertex equal charge

- same sign.
- regular polygon
- F=0 at center.



Fnet = 0



Coulomb's Law in Vector Form

$$\boxed{\hat{A} = \frac{\vec{A}}{A}}$$

→ unit vector

→ tell's us direction.

$$\boxed{\vec{F} = \frac{kq_1q_2}{r^2}\hat{r}}$$

$$\vec{F} = \frac{kq_1q_2}{r^2} \times \frac{\vec{r}}{r} \Rightarrow \boxed{\vec{F} = \frac{kq_1q_2}{r^3}\vec{r}}$$

- Put q_1, q_2 with sign.

QUESTION

An electron is moving round the nucleus of a hydrogen atom in a circular orbit of radius r. The coulomb force F between the two is **[CBSE AIPMT 2003]**

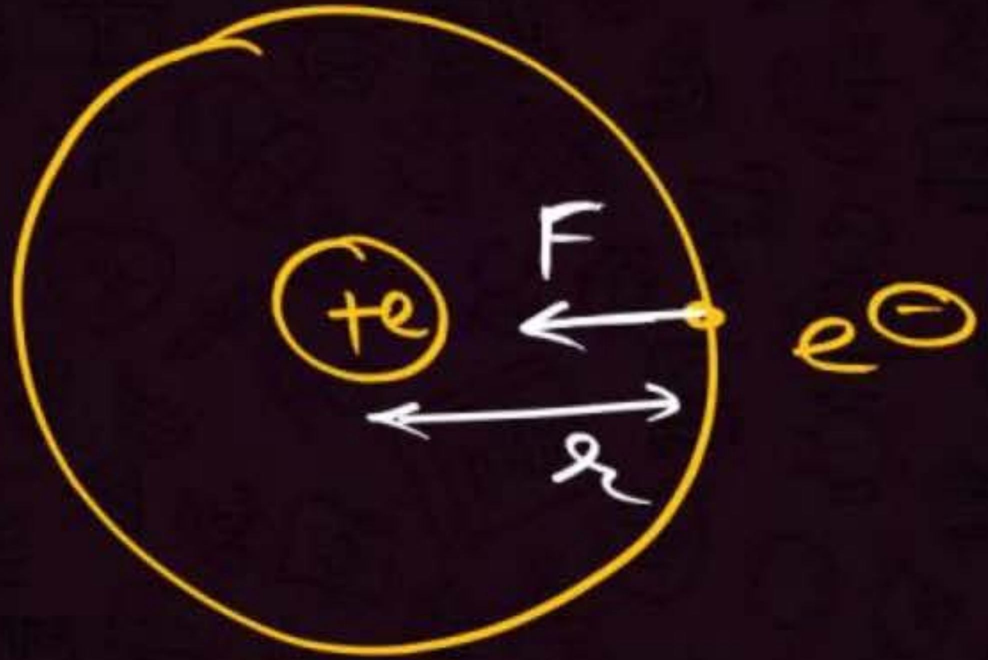
① $k\frac{e^2}{r^3}\vec{r}$ ×

[✓ ② $-k\frac{e^2}{r^3}\vec{r}$]

③ $k\frac{e^2}{r^2}\hat{r}$ ×

④ $-k\frac{e^2}{r^3}\hat{r}$ ×

(Where, $k = \frac{1}{4\pi\varepsilon_0}$)

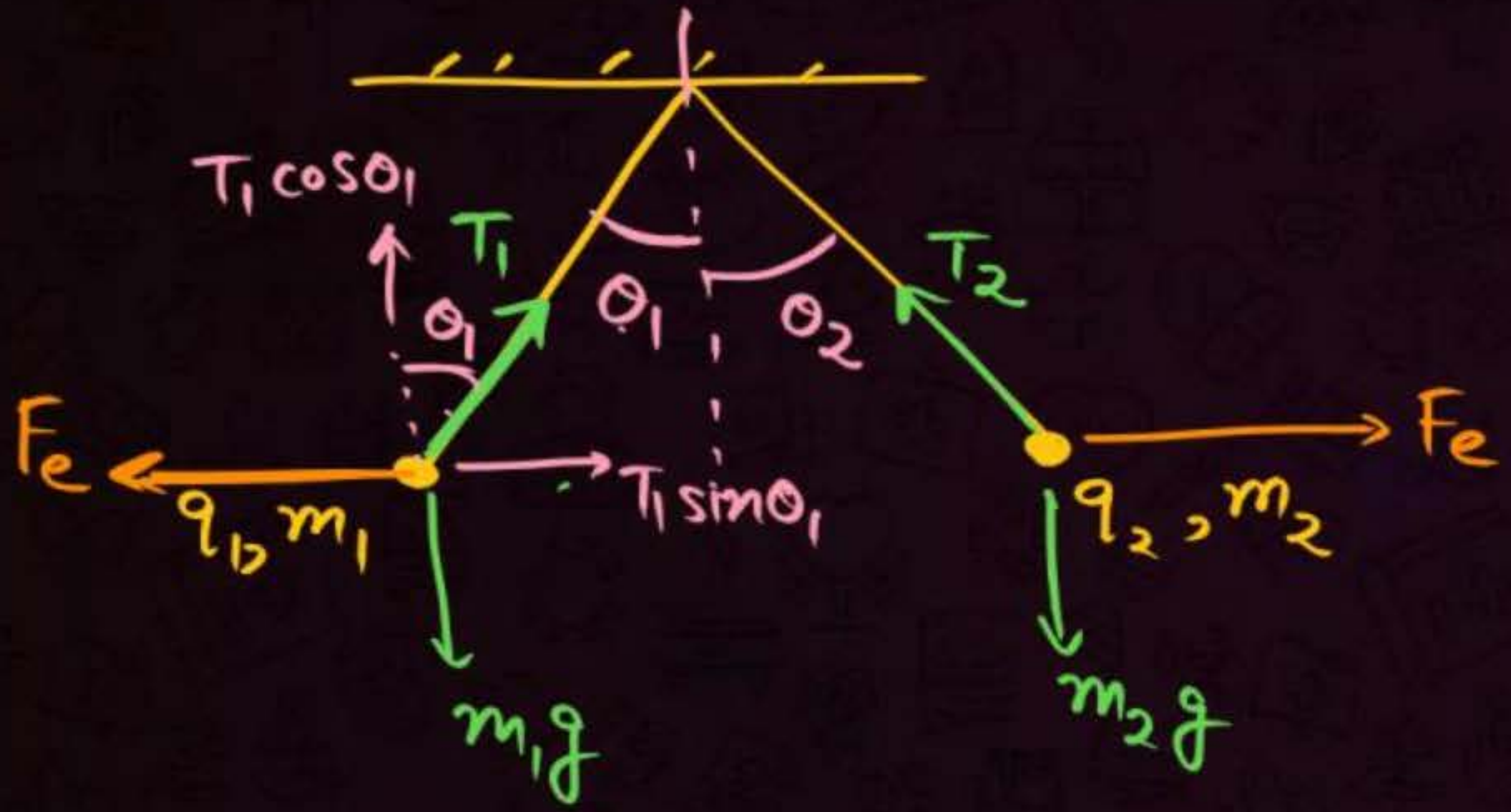


$$\vec{F} = \frac{k(+e)(-e)}{r^2}\hat{r}$$

$$\vec{F} = \frac{-ke^2}{r^2}\hat{r}$$

$$\vec{F} = \frac{-ke^2}{r^3}\vec{r}$$

QUESTIONS ON PENDULUM



$$T_1 \cos\theta_1 = m_1 g \quad — ①$$

$$T_1 \sin\theta_1 = F_e \quad — ②$$

② / ①

$$\frac{\cancel{T_1} \sin\theta_1}{\cancel{T_1} \cos\theta_1} = \frac{F_e}{m_1 g}$$

✓ $$\boxed{\tan\theta_1 = \frac{F_e}{m_1 g}}$$

✓ $$\boxed{\tan\theta_2 = \frac{F_e}{m_2 g}}$$

$$\boxed{\frac{\tan\theta_1}{\tan\theta_2} = \frac{m_2}{m_1}}$$

$$\Downarrow$$

independent of charge.

QUESTION

If $q_1 > q_2$ but $m_1 = m_2$ then find relation between θ_1 and θ_2.

① $\theta_1 > \theta_2$

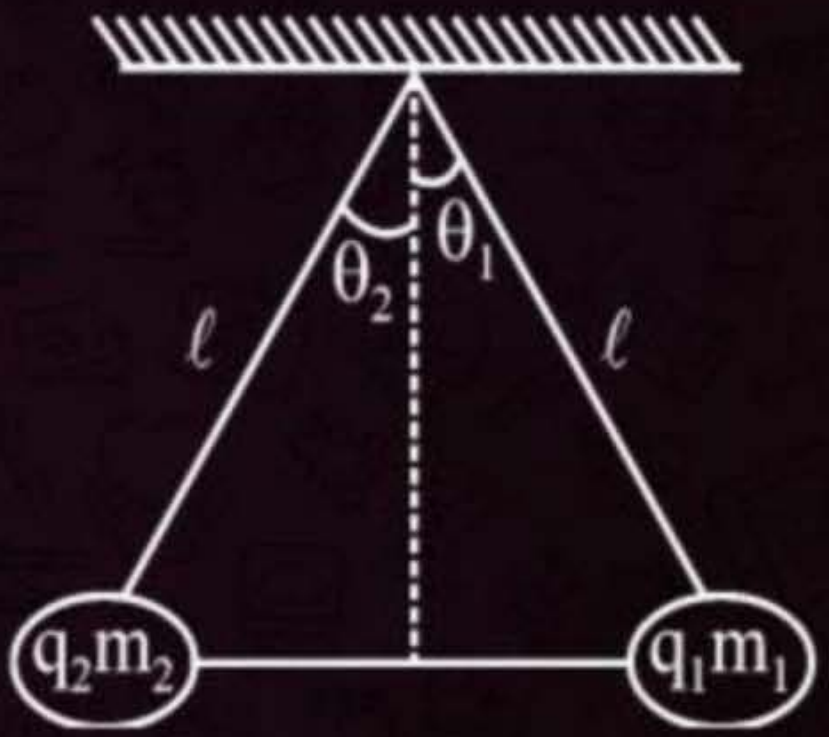
② $\theta_1 < \theta_2$

[✓ ③ $\theta_1 = \theta_2$]

④ Humein Kya Pta!

$$\frac{\tan\theta_1}{\tan\theta_2} = \frac{m_2}{m_1} = 1$$

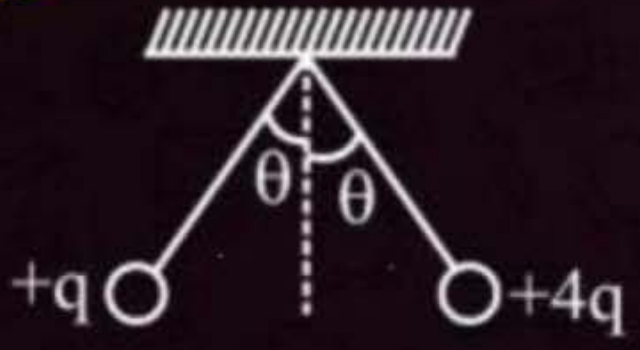
$$\boxed{\theta_1 = \theta_2}$$



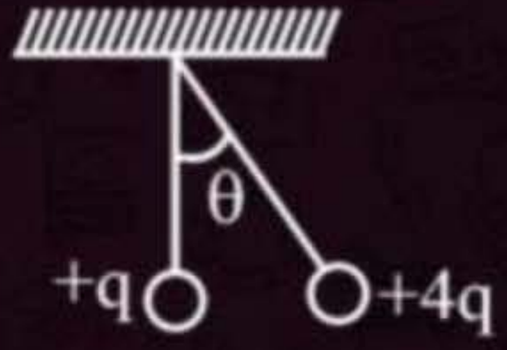
QUESTION

Two metal spheres of same mass are suspended from a common point by a light insulating string. The length of each string is same. the sphere are given electric charges $+q$ on one end and $+4q$ on the other. Which of the following diagrams best shows the resulting positions of sphere?

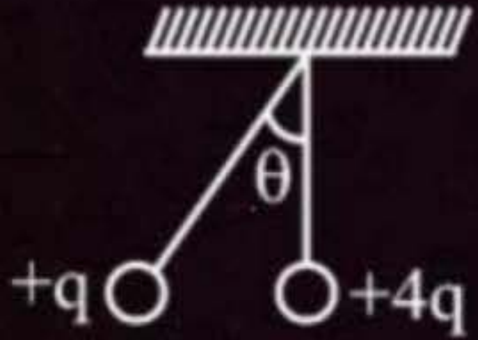
[✓ 1]



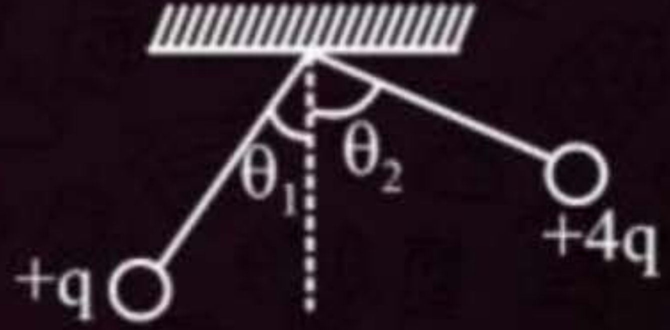
2



3

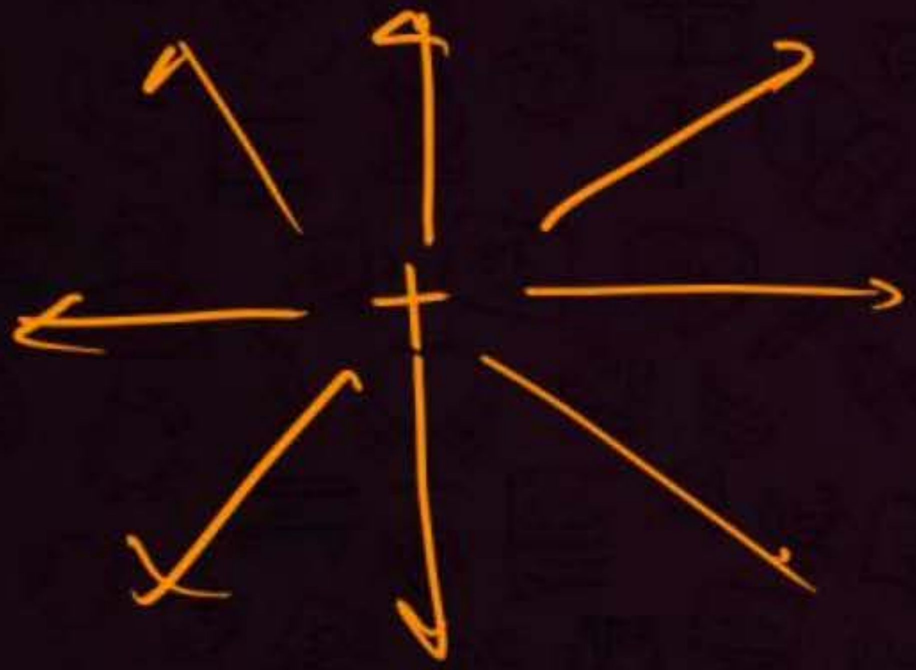


4



Sher ka Khauff (ELECTRIC FIELD)

The space around a charge where its effect can be felt.



ELECTRIC FIELD STRENGTH (E)/Intensity of Electric Field

Force experienced per unit positive test charge.

$$F = \frac{k q q_0}{r^2}$$

$$\boxed{\frac{F}{q_0} = E = \frac{kq}{r^2}} \longrightarrow \infty$$

r

Sher

q ↓ Source

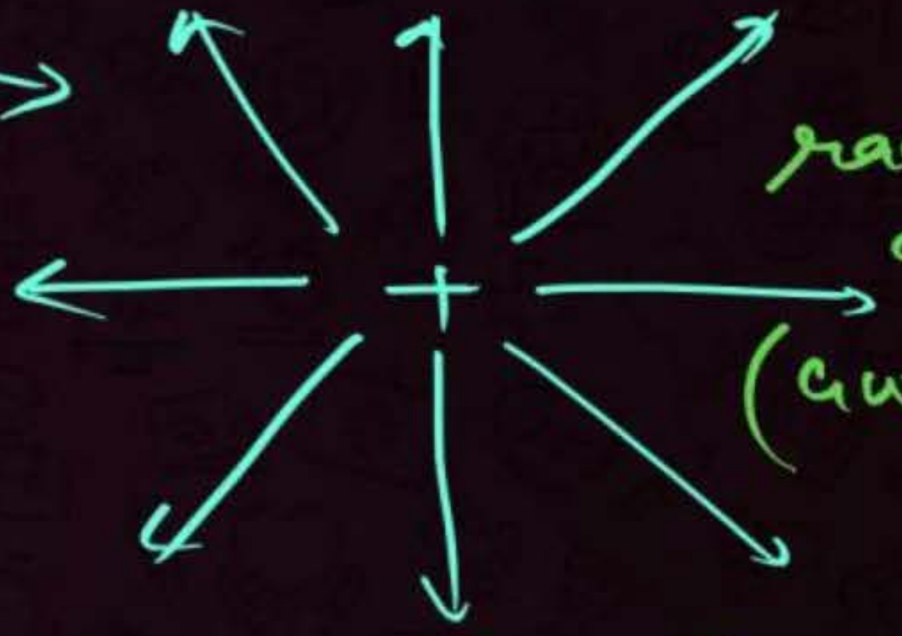
q_0 ↓ Test charge

Bakri

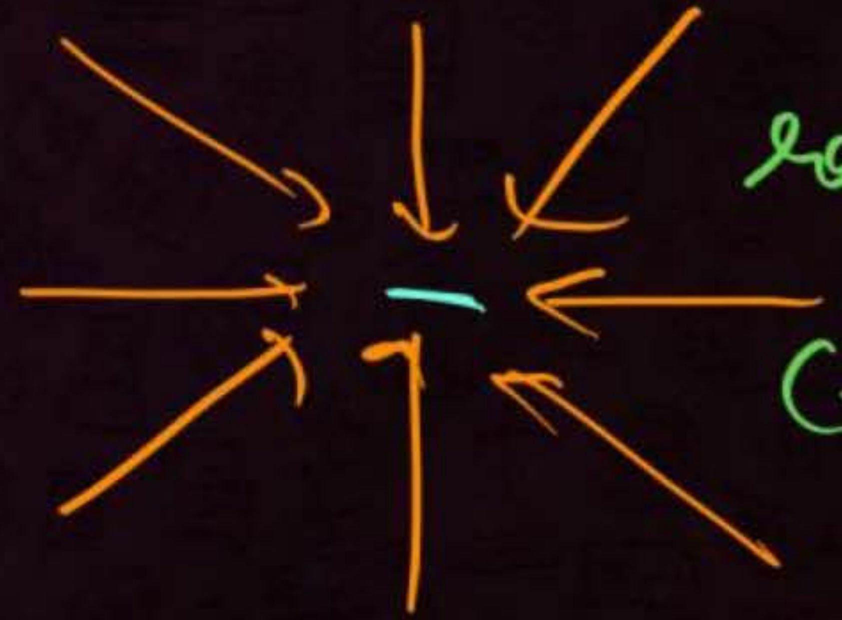
SI Unit, Graph and Field lines for a point charge

$$E = \frac{F}{q_0} \Rightarrow \boxed{\frac{N}{C}} \text{ or } \boxed{\frac{V}{m}}$$

$$\text{Pt. charge} \Rightarrow E = \frac{kq}{r^2} \Rightarrow E \propto \frac{1}{r^2}$$

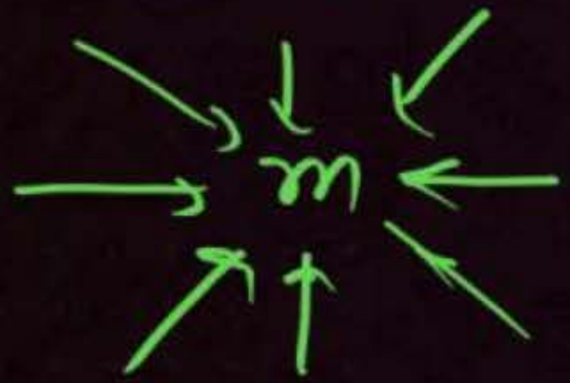


radially outwards (away)



radially inwards (towards)

Grav. field



QUESTIONS

Find electric field due to a point charge in each case:

① 8 C at a distance of 4 m $\Rightarrow \dfrac{9\times10^{9}\times 8}{4^2}$

② 10 μC at a distance of 3 m $\Rightarrow \dfrac{9\times10^{9}\times 10\times10^{-6}}{3^2}$

③ 9 nC at a distance of 9 cm $\Rightarrow \dfrac{9\times10^{9}\times 9\times10^{-9}}{(9\times10^{-2})^2}$

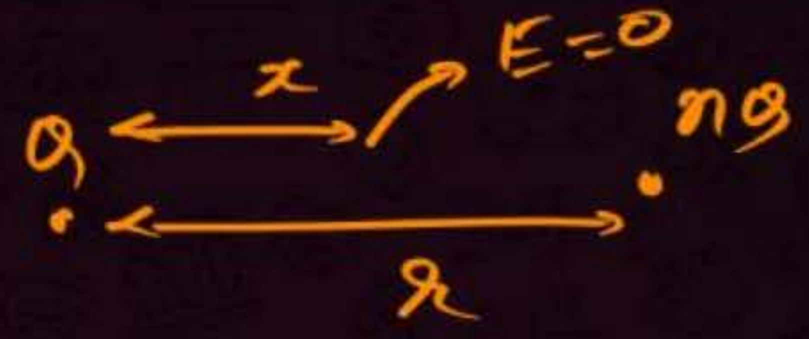
Electric Field due to multiple charges

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

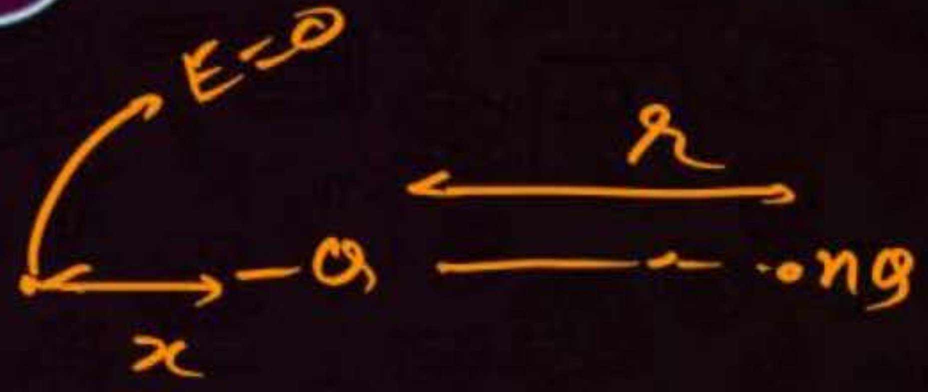
$$\boxed{F = q_0 E}$$

If $F = 0$

$E = 0$

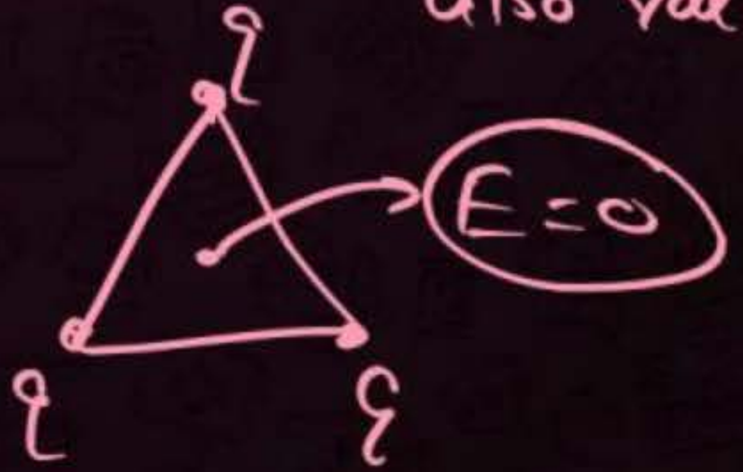


$$x = \frac{r}{\sqrt{n}+1}$$



$$\frac{r}{\sqrt{n}-1}$$

* Same regular polygon also valid.



QUESTION

Charges 2Q and –Q are placed as shown in the figure. The point at which electric field is zero is somewhere

① Between –Q and 2Q ×

[✓ ②] On the left of –Q

③ On the right of 2Q ×

④ On the perpendicular bisector of the line joining the charges ×

QUESTION

ABC is an equilateral triangle. Charges $+q$ are placed at each corner. The electric field intensity at the centroid of triangle will be

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

② $\frac{1}{4\pi\varepsilon_0} \times \frac{3q}{r^2}$

③ $\frac{1}{4\pi\varepsilon_0} \times \frac{q}{r}$

[✓ ④ Zero]

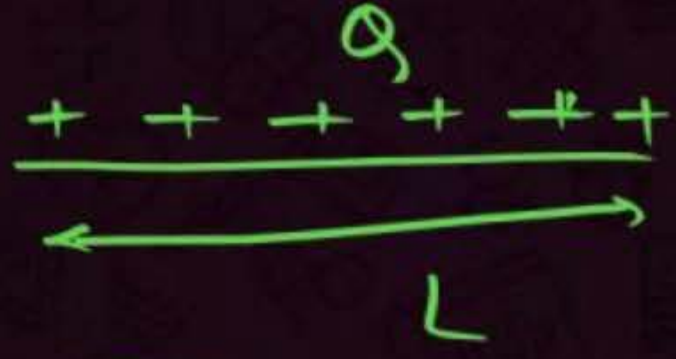
CONTINUOUS CHARGE DISTRIBUTIONS

Discrete

↓

alag-alag

① Linear Charge density (λ)



$$\boxed{\lambda = \frac{q}{L}} \Rightarrow \frac{C}{m}$$

② surface charge density (σ)

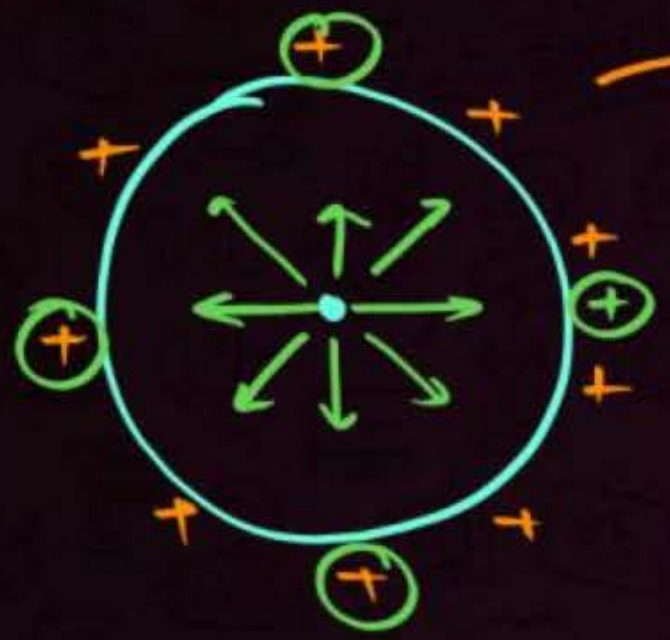
$$\boxed{\sigma = \frac{q}{A}} \Rightarrow \frac{C}{m^2}$$

Sheet

③ Volume Charge density (ρ)

$$\boxed{\rho = \frac{q}{V}} \Rightarrow \frac{C}{m^3}$$

1. Electric Field due to a ring at Centre



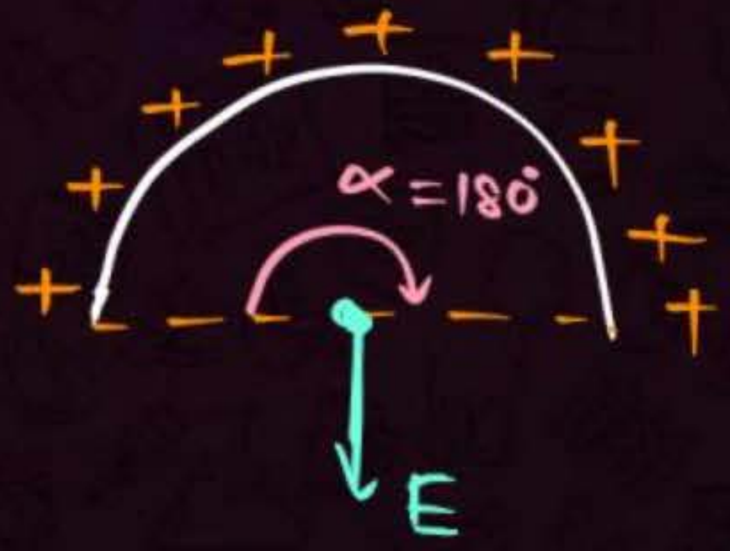
→ uniformly charged

$\boxed{E = 0}$ at center

2. Electric Field due to a circular arc

$$\boxed{E = \frac{2k\lambda}{R}\sin\left(\frac{\alpha}{2}\right)}$$

- Semi-circular arc



$$E = \frac{2k\lambda}{R}\sin\left(\frac{180}{2}\right)$$

$$E = \frac{2k\lambda}{R}\sin 90^\circ$$

$$\boxed{E = \frac{2k\lambda}{R}}$$

- Quarter circle

$$E = \frac{\sqrt{2}k\lambda}{R}$$

QUESTION

Electric field at centre O of semicircle of radius a having linear charge density λ given as.

[2000]

① $\frac{\lambda}{2\pi\varepsilon_0 a^2}$

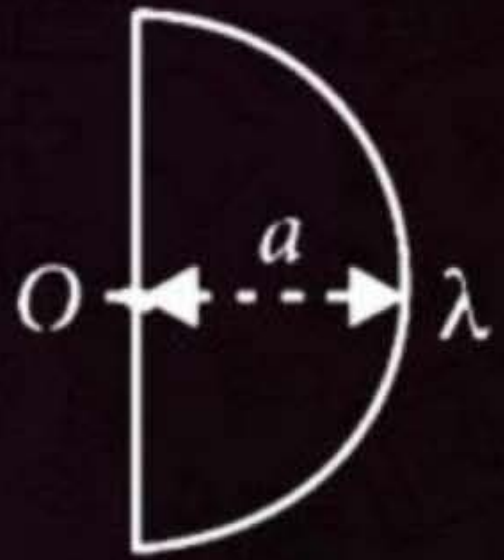
② $\frac{\lambda}{4\pi^2\varepsilon_0 a^2}$

③ $\frac{\lambda^2}{2\pi\varepsilon_0 a}$

[✓ ④] $\frac{\lambda}{2\pi\varepsilon_0 a}$

$$E = \frac{2k\lambda}{a} = \cancel{2}\times\frac{1}{\underset{2}{\cancel{4}}\pi\epsilon_0}\times\frac{\lambda}{a}$$

$$= \frac{\lambda}{2\pi\epsilon_0 a}.$$



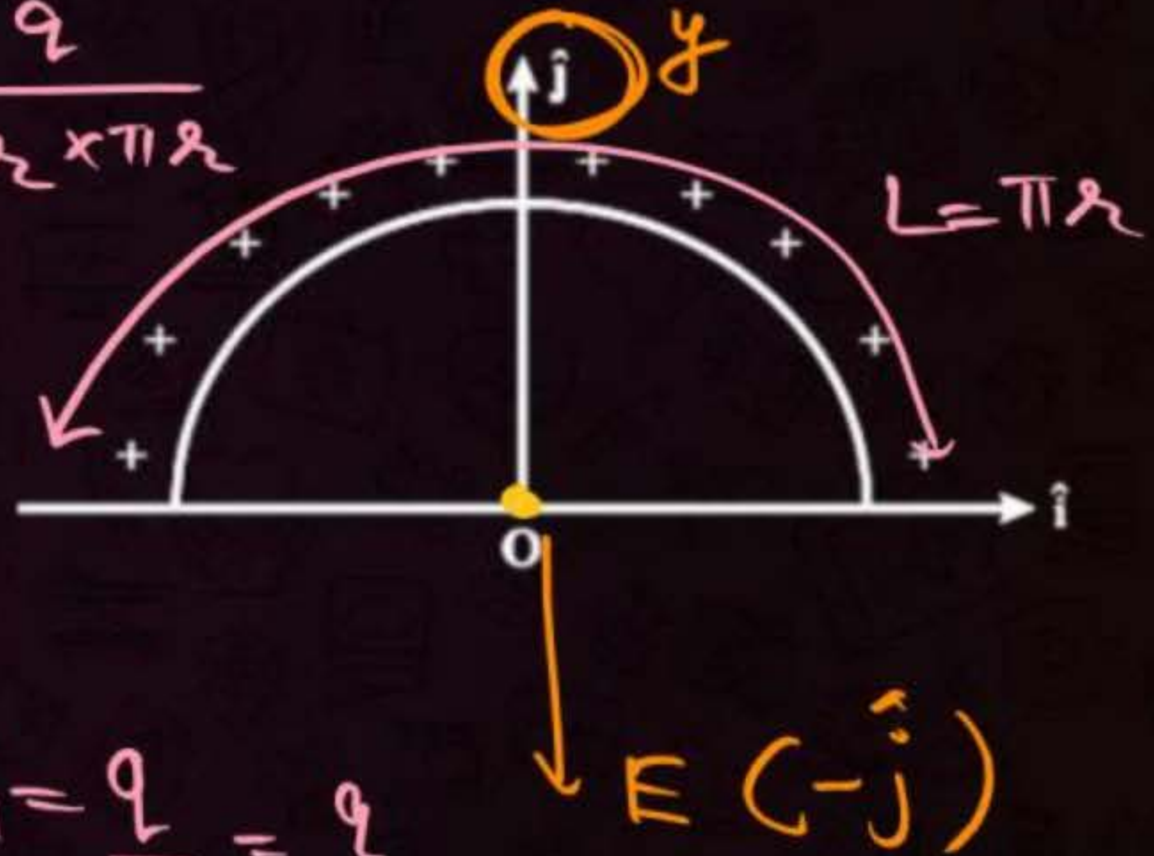
QUESTION

A thin semi-circular ring of radius r has a positive charge q distributed uniformly over it. The net field $\vec{E}$ at the centre O is

1. $\frac{q}{4\pi^2\varepsilon_0 r^2}\hat{j}$
2. $-\frac{q}{4\pi^2\varepsilon_0 r^2}\hat{j}$ ×
3. $-\frac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$
4. $\frac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$

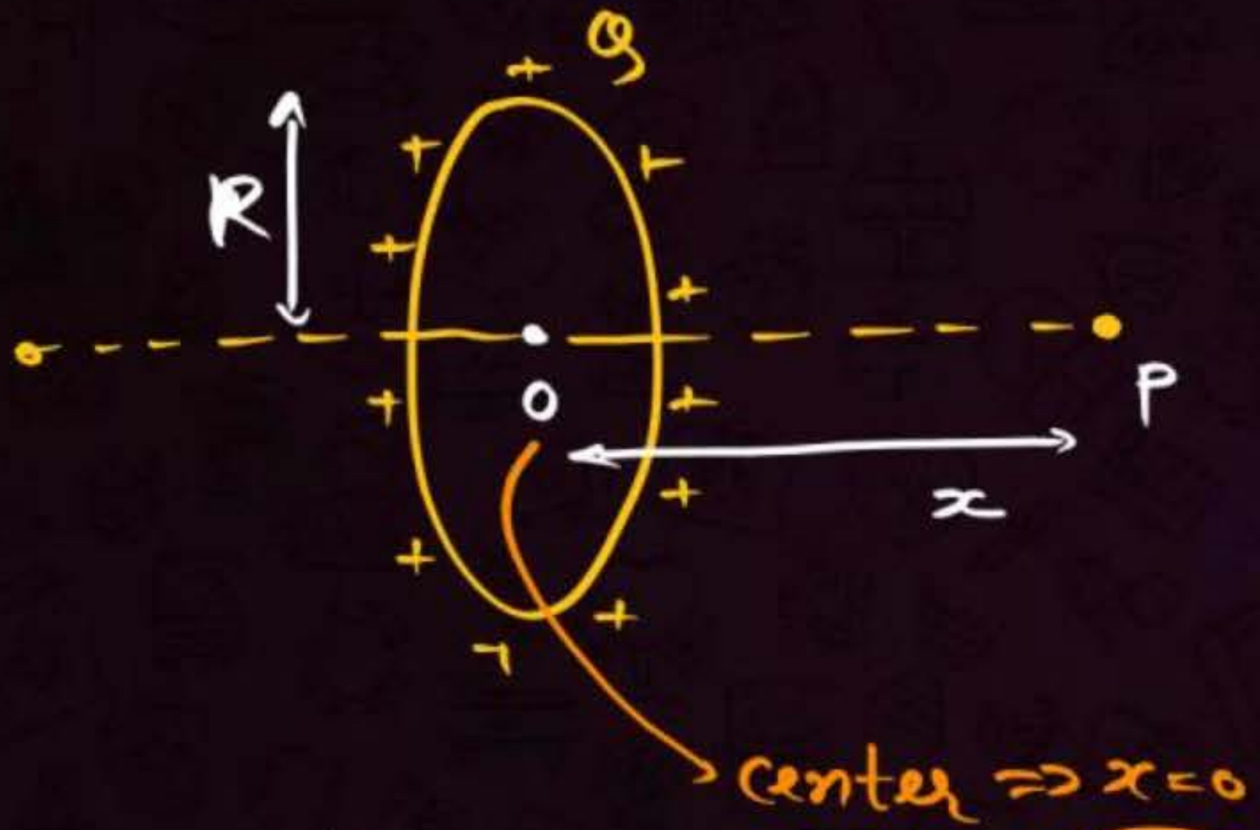
$$E = \frac{2k\lambda}{r} = \cancel{2}\times\frac{1}{\underset{2}{\cancel{4}}\pi\epsilon_0}\times\frac{q}{r\times\pi r}$$

$$= \frac{q}{2\pi^2\epsilon_0 r^2}$$



$$\lambda = \frac{q}{L} = \frac{q}{\pi r}$$

3. Electric Field due to ring at an axis



center ⇒ $x=0$

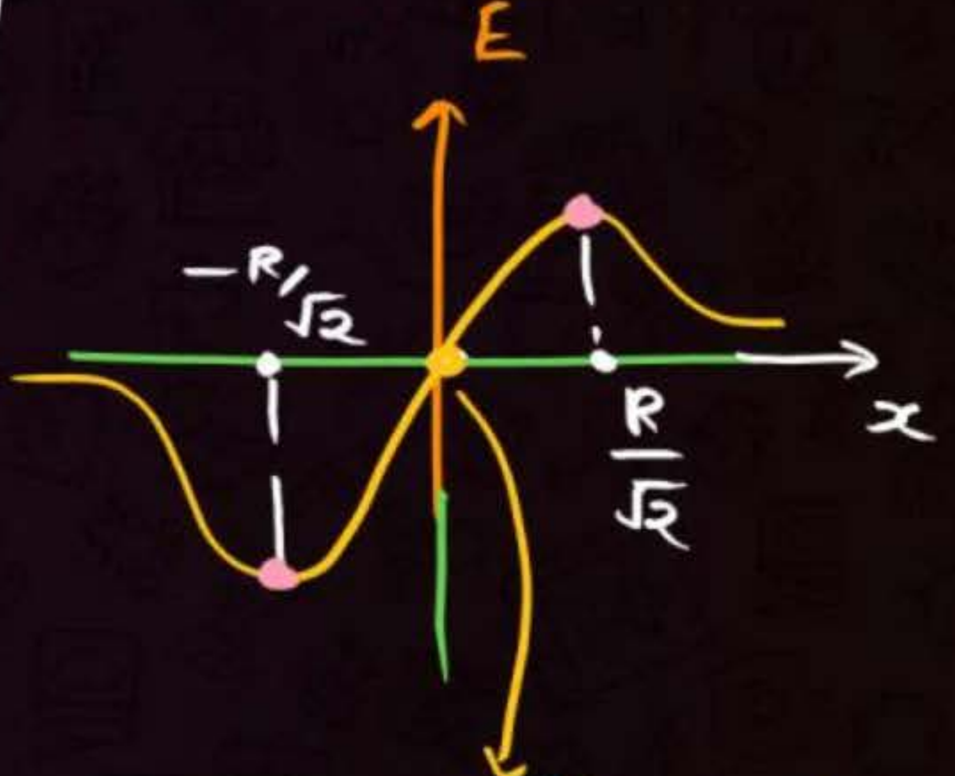
$\boxed{E=0}$

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

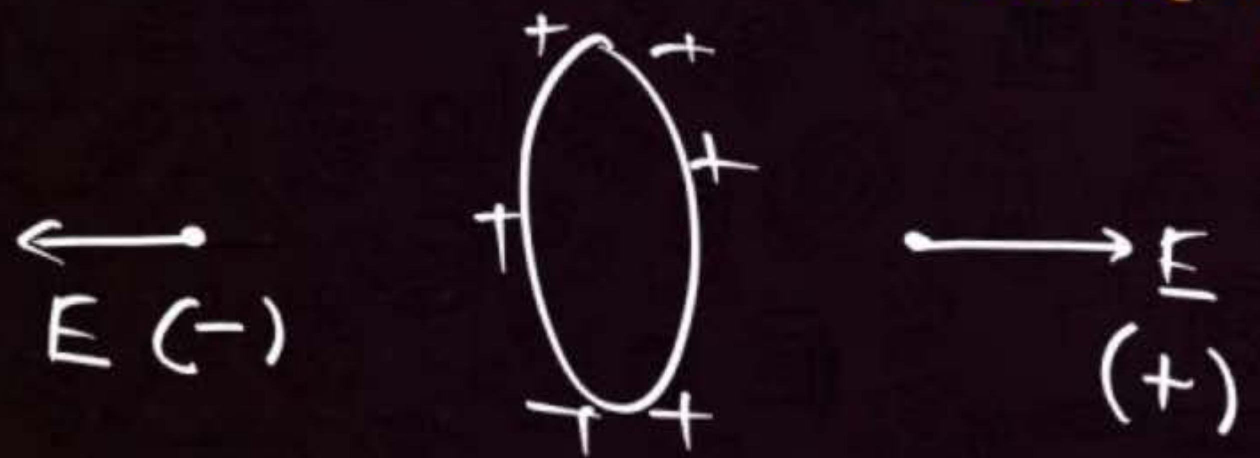
↓

E max at

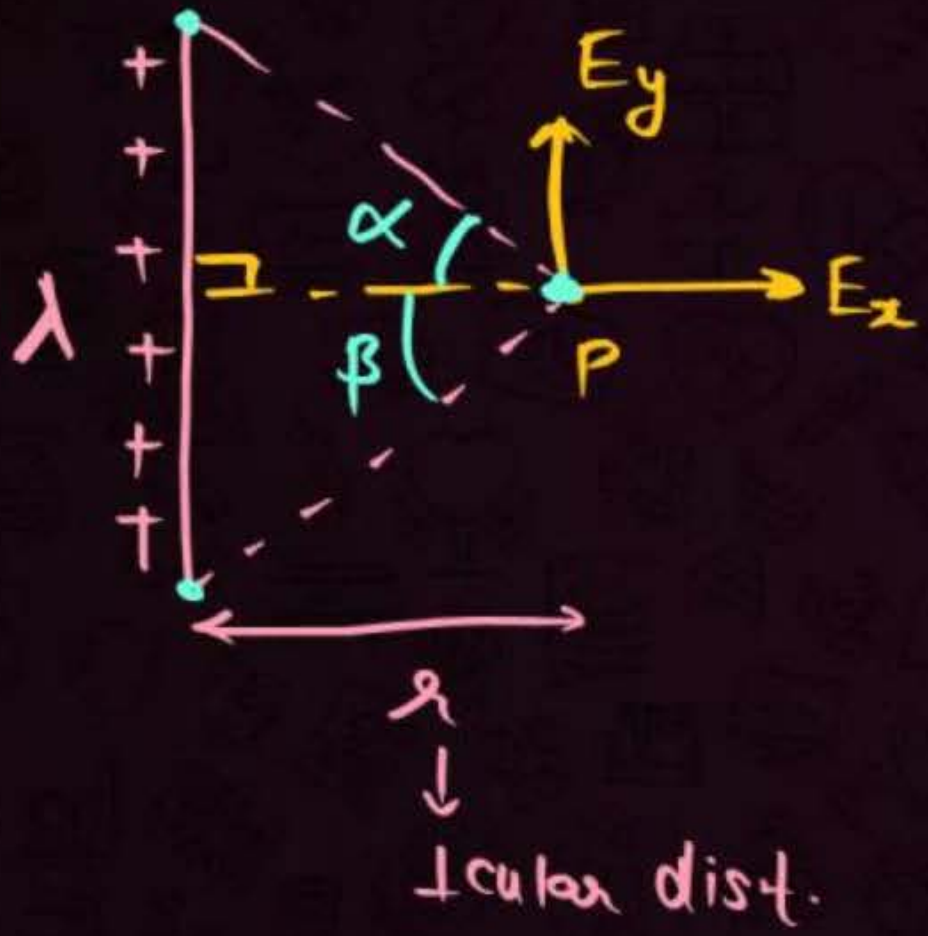
$$\boxed{x = \pm \frac{R}{\sqrt{2}}}$$



Emin $=0$



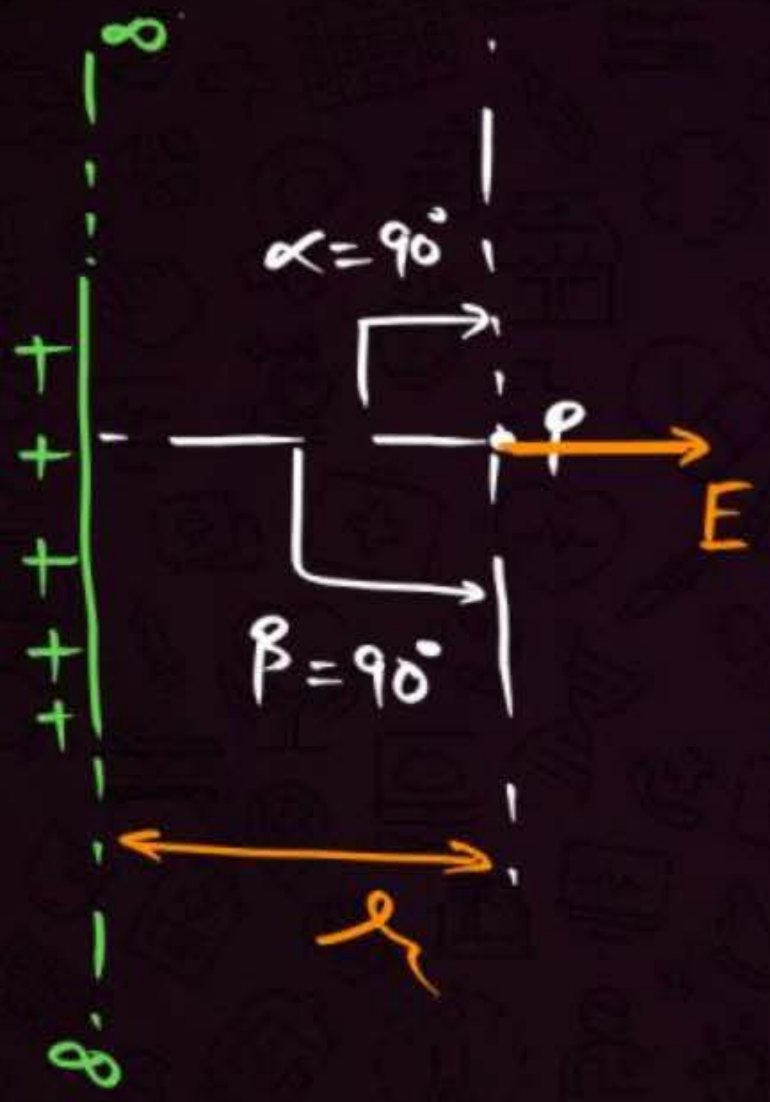
4. Electric Field due to a charged rod



$$E_x = \frac{k\lambda}{r}\left[\sin\alpha + \sin\beta\right]$$

$$E_y = \frac{k\lambda}{r}\left[\cos\alpha - \cos\beta\right]$$

① Infinite rod



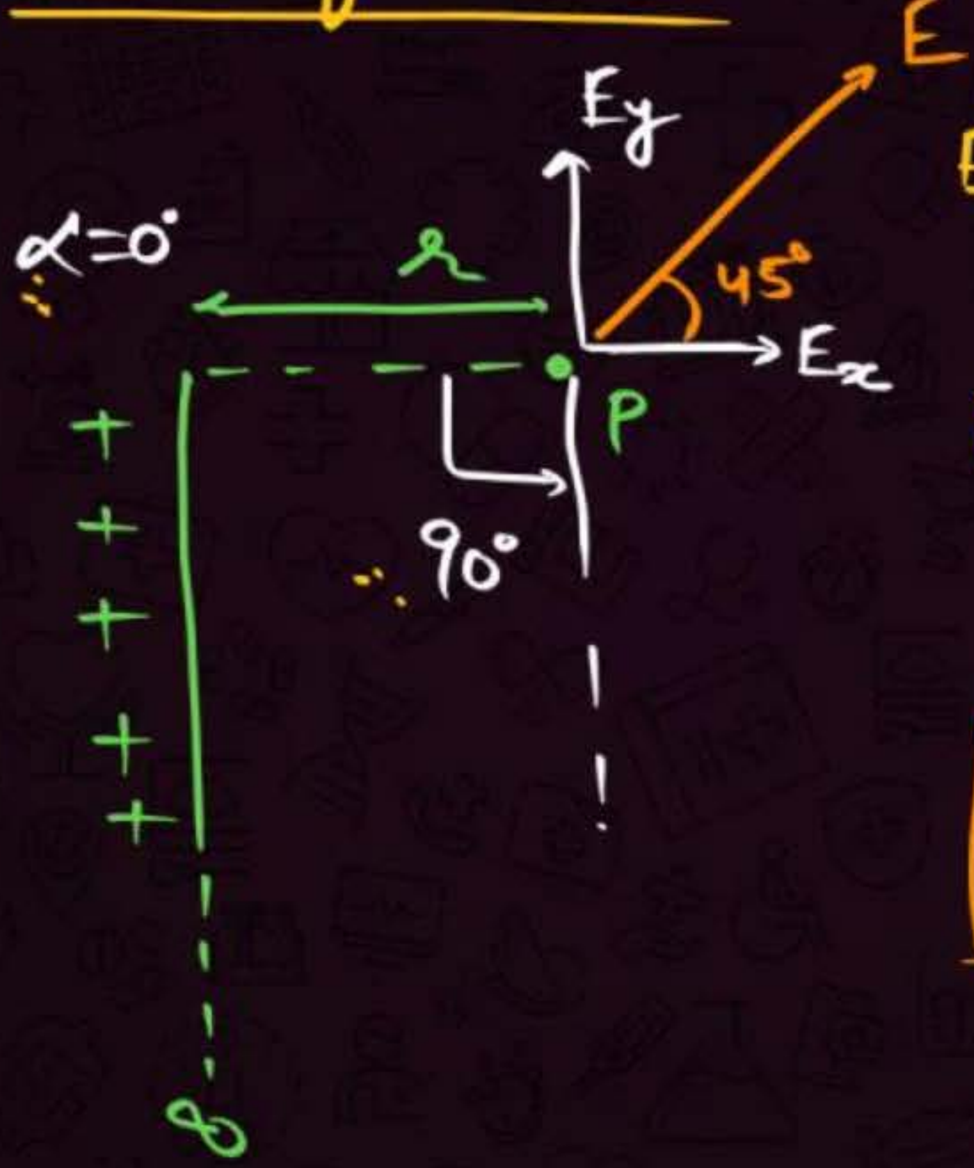
$$E_x = \frac{k\lambda}{r}[1+1] = \frac{2k\lambda}{r}$$

$$E_y = \frac{k\lambda}{r}[0-0] = 0$$

$$\boxed{E = \frac{2k\lambda}{r}}$$

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

② Semi-infinite rod



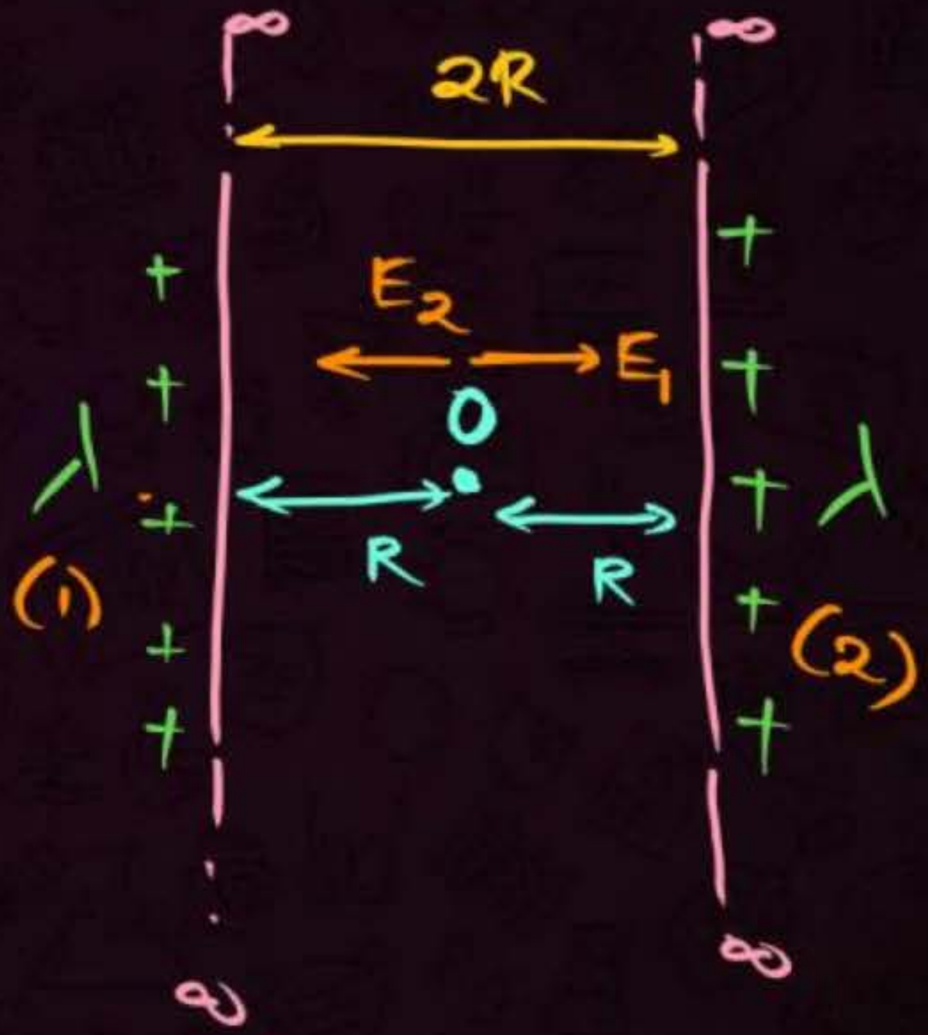
$$E_x = \frac{k\lambda}{r}[0+1] = \frac{k\lambda}{r}$$

$$E_y = \frac{k\lambda}{r}[1-0] = \frac{k\lambda}{r}$$

$$\boxed{E = \sqrt{2}\,\frac{k\lambda}{r}}$$

QUESTION

Two parallel infinite line charges with linear charge densities $+\lambda$ C/m and $+\lambda$ C/m are placed at a distance of 2R in free space. What is the electric field mid-way between the two line charges?



[✓ ① Zero]

② $\frac{2\lambda}{\pi\varepsilon_0 R}$ N/C

③ $\frac{\lambda}{\pi\varepsilon_0 R}$ N/C

④ $\frac{\lambda}{2\pi\varepsilon_0 R}$ N/C

QUESTION

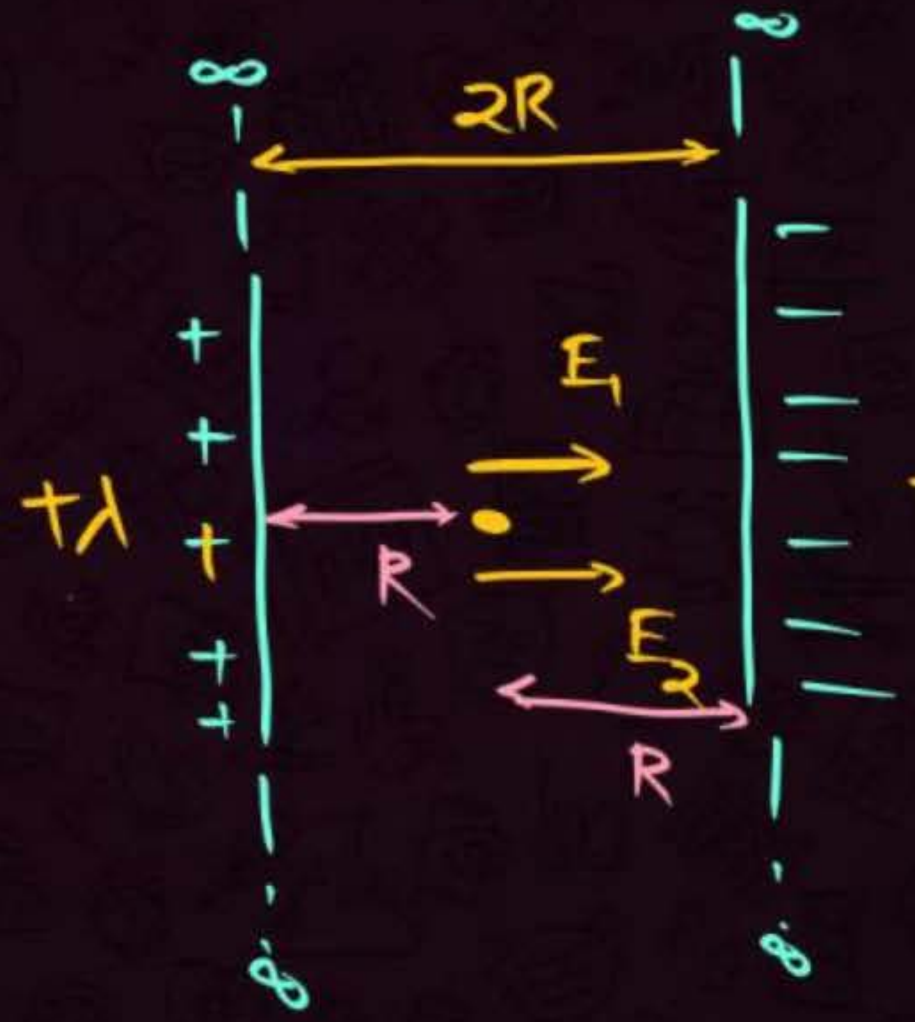
Two parallel infinite line charges with linear charge densities $+\lambda$ C/m and $-\lambda$ C/m are placed at a distance of 2R in free space. What is the electric field mid-way between the two line charges?

① Zero

② $\frac{2\lambda}{\pi\varepsilon_0 R}$ N/C

[✓ ③] $\frac{\lambda}{\pi\varepsilon_0 R}$ N/C

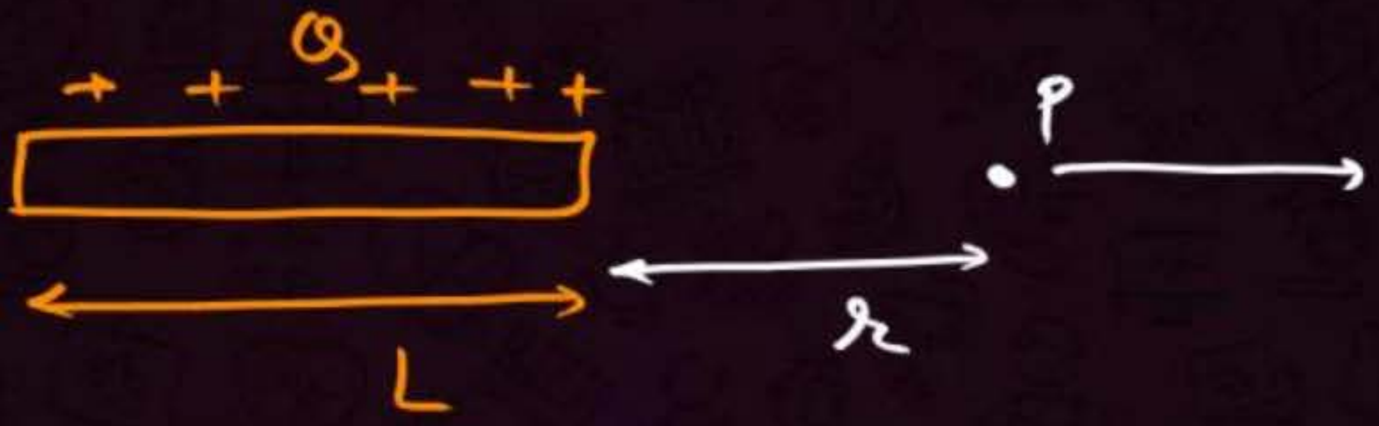
④ $\frac{\lambda}{2\pi\varepsilon_0 R}$ N/C



$$E = 2E$$
$$= 2 \times \frac{2k\lambda}{R}$$
$$= \frac{4k\lambda}{R}$$
$$= \cancel{4} \times \frac{1}{\cancel{4}\pi\epsilon_0} \times \frac{\lambda}{R}$$
$$= \frac{\lambda}{\pi\epsilon_0 R}$$

Axial Point of Rod

→ Rare chance

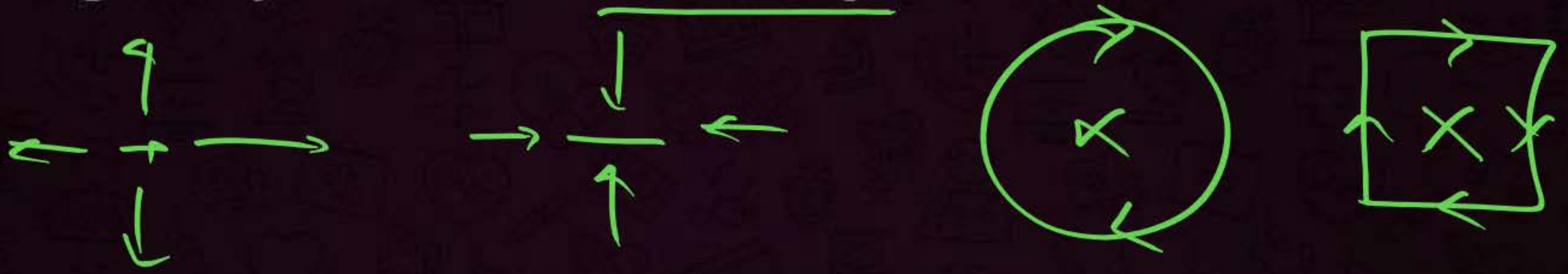


$$\boxed{E = \frac{kQ}{r(r+L)}}$$

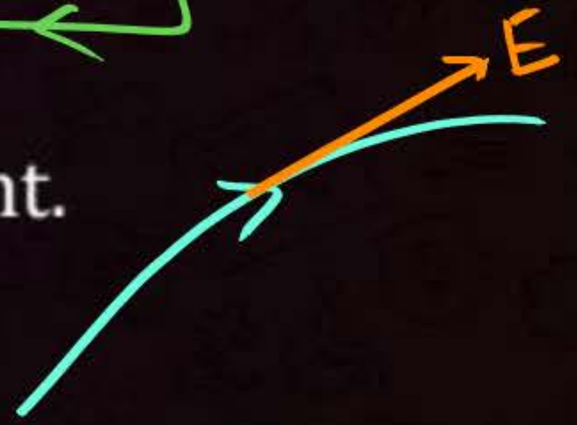
☆ PPt change Break ⇒ 5 min

ELECTRIC FIELD LINES AND ITS PROPERTIES

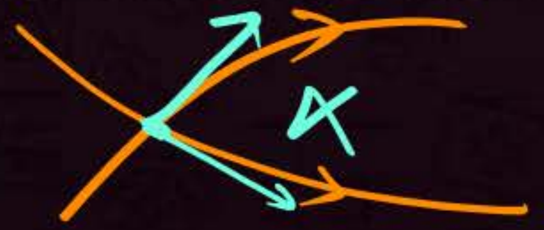
1. These are imaginary lines starting from positive charge and terminating at negative charge. They do not form closed loops.



2. Tangent to the field gives us the direction of electric field at that point.



3. Two field lines can never intersect each other. Because at point of intersection, there will be two directions of electric field, which is not possible.

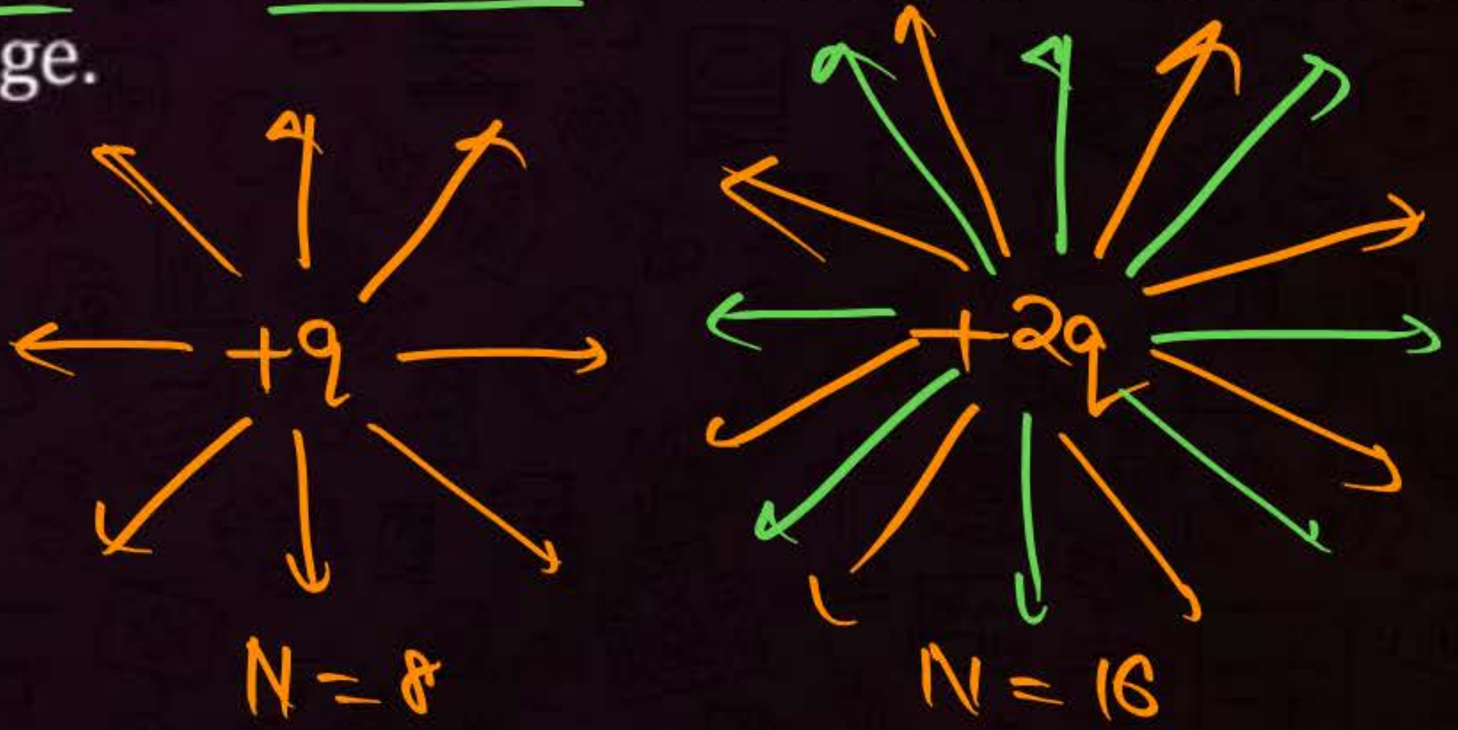


4. The magnitude of electric field is directly proportional to the number of field lines in a given space.

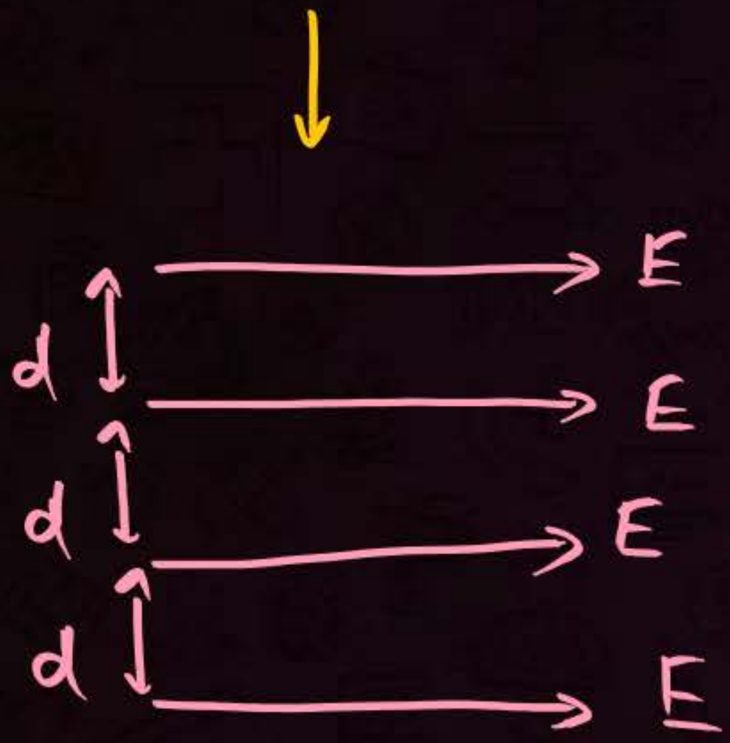
5. Number of electric field lines originating or terminating at a charge is directly proportional to the magnitude of the charge.

$\boxed{\text{No. of Lins} \propto q}$

eg:-



6. Uniform and Non-uniform Electric Field



gap → same.

direction → same

QUESTION

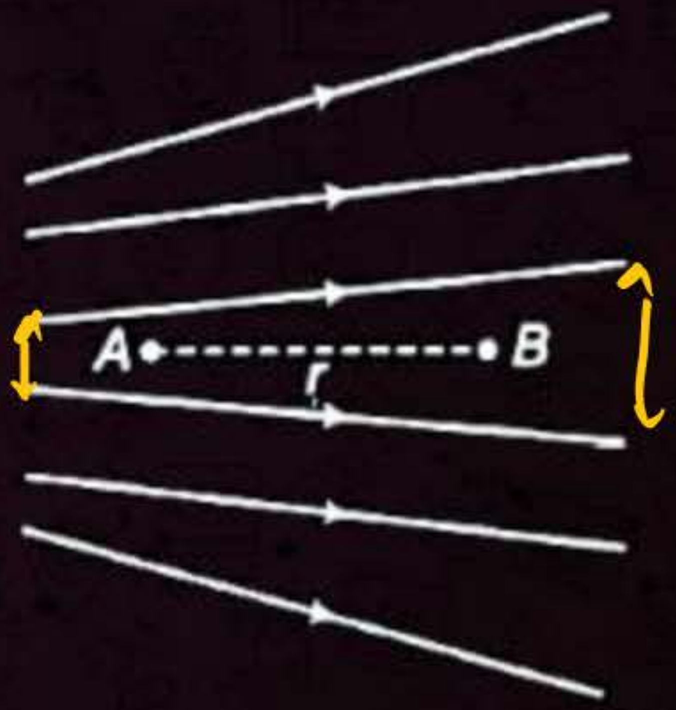
Figure shows the electric lines of force emerging from a charged body. If electric field at A and B are E_A and E_B respectively and distance between A and B is r then

[✓ ① $E_A > E_B$]

② $E_A = E_B/r$

③ $E_A < E_B$

④ $E_A = E_B/r^2$



QUESTION

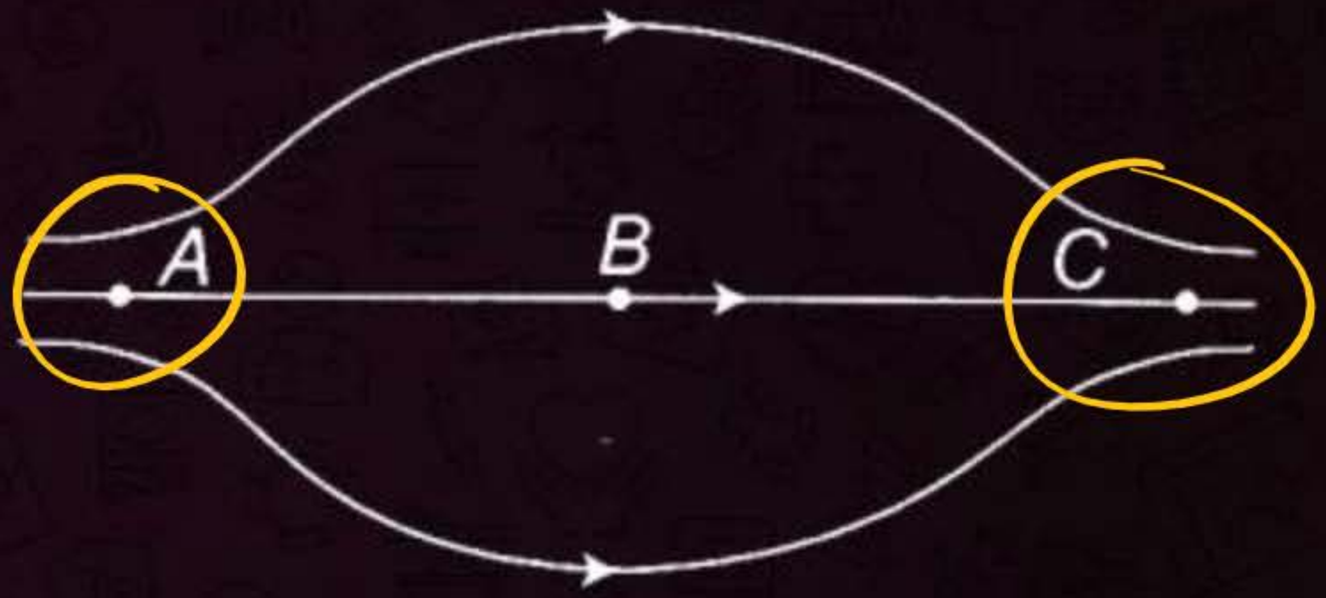
Figure shows some of the electric field lines corresponding to an electric field. The figure suggests that

① $E_A > E_B > E_C$

② $E_A = E_B = E_C$

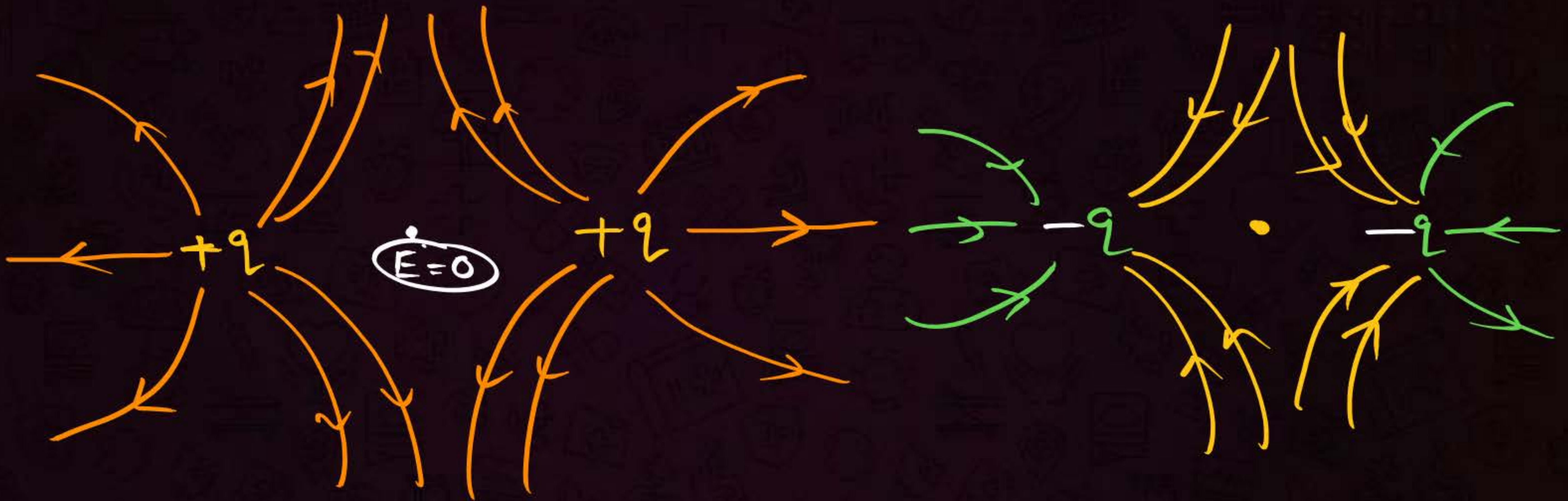
[✓ ③ $E_A = E_C > E_B$]

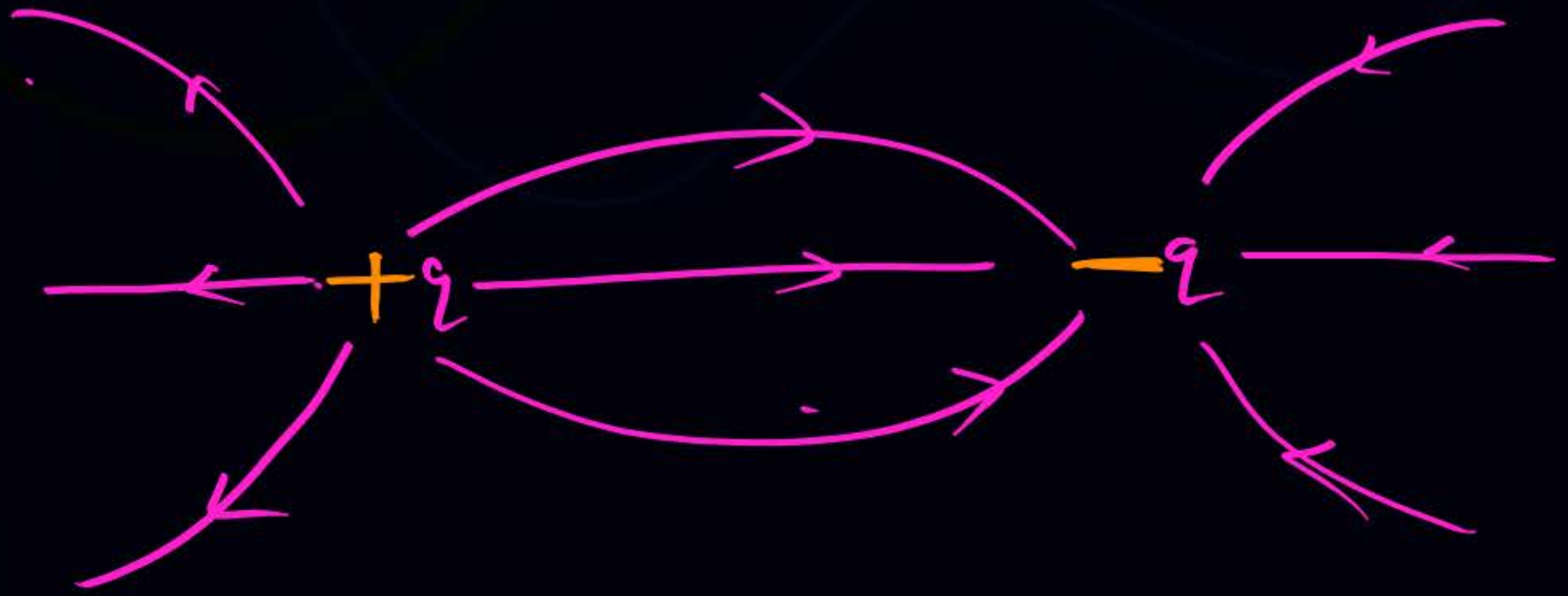
④ $E_A = E_C < E_B$



$E_A = E_C > E_B$

Electric Field lines due to two charge combination





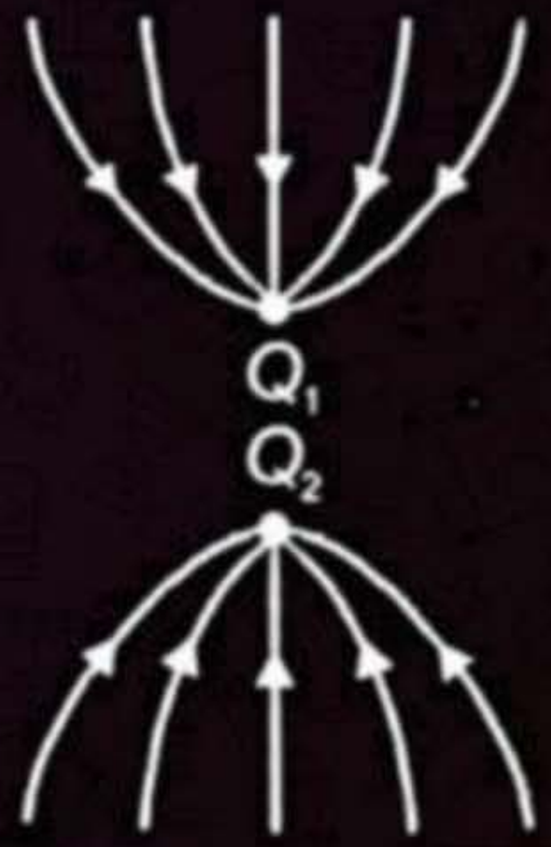
+ve & -ve

QUESTION

The figure shown is a plot of electric field lines due to two charges Q_1 and Q_2. The sign of charges is

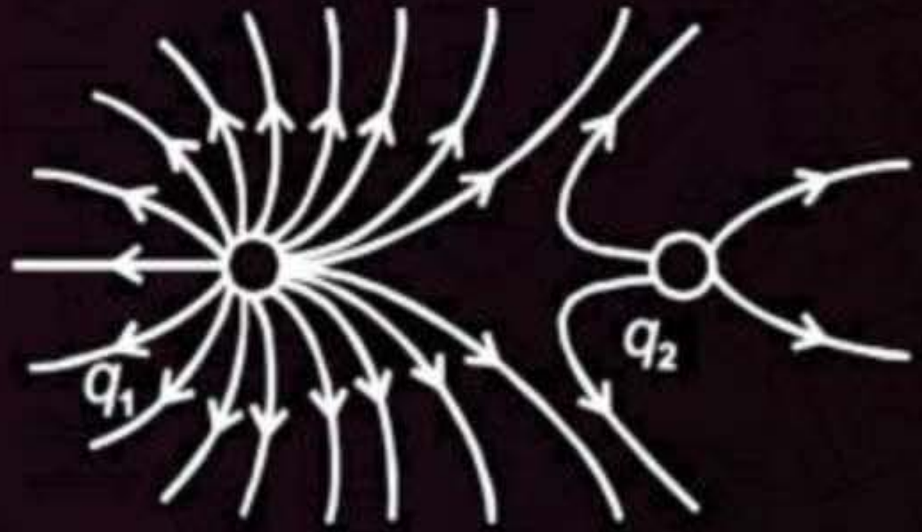
(1994)

1. [✓ Both negative]
2. Both positive
3. Q_1 positive, Q_2 negative
4. Q_1 negative, Q_2 positive



QUESTION

Figure shows electric field lines due to a charge configuration, from this we conclude that

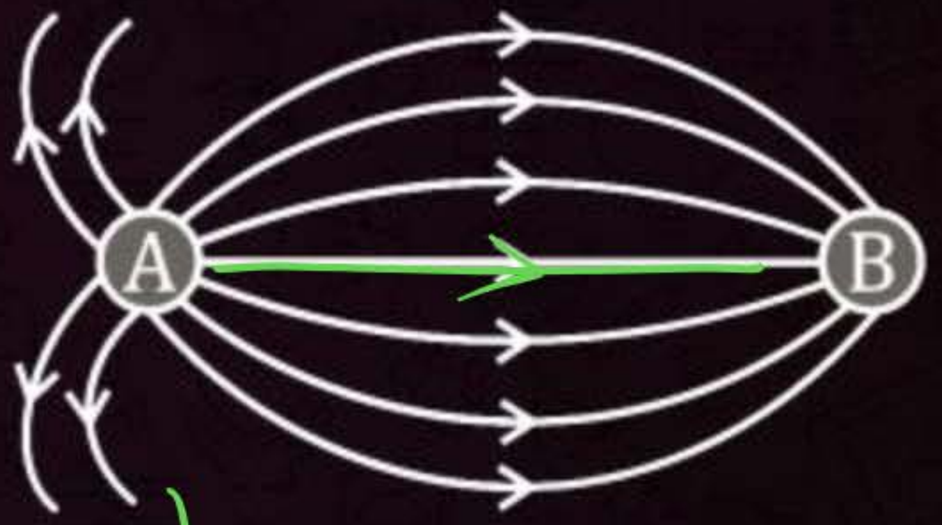


1. q_1 and q_2 are positive and $q_2 > q_1$
2. [✓ q_1 and q_2 are positive and $q_1 > q_2$]
3. q_1 and q_2 are negative and $q_1 > q_2$ ✗
4. q_1 and q_2 are negative and $q_2 > q_1$ ✗

QUESTION

The spatial distribution of the electric field due to charges (A, B) is shown in figure. Which one of the following statement is correct

1. ✓ A is +ve and B is –ve; |A| > |B| → No Use
2. A is –ve and B is +ve; |A| = |B| ✗
3. Both are +ve but A > B ✗
4. Both are –ve but A > B ✗



more field lines

Force on charge particle in External Electric Field

$$+q \Rightarrow \vec{F} = +q\vec{E}$$

$$-q \Rightarrow \vec{F} = -q\vec{E}$$

QUESTION

Figure shows three electric field lines. If F_A, F_B and F_C are forces on a test charge q at position A, B and C respectively, then

[✓ ①] $F_A > F_B > F_C$

② $F_A < F_B < F_C$

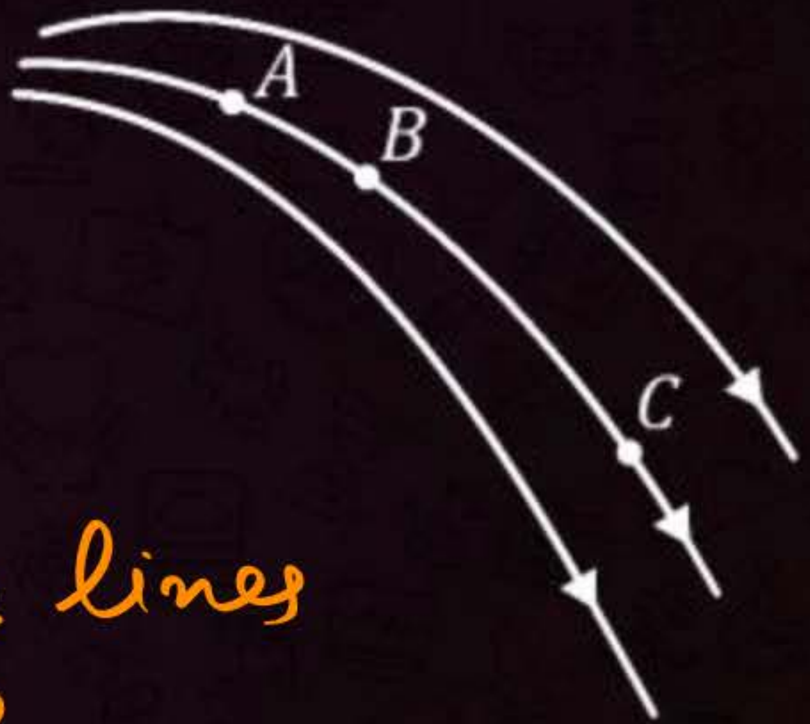
③ $F_A > (F_B = F_C)$

④ $F_A < (F_B = F_C)$

$E_A > E_B > E_C$

$q E_A > q E_B > q E_C$

$F_A > F_B > F_C$



Field Lines → electric lines of force

QUESTION

$q = +e$ $q = -e$

Assertion (A): If a proton and an electron are placed in the same uniform electric field then they experience different acceleration.

$\boxed{F = qE} \rightarrow$ equal

Reason (R): Electric force on a test charge is independent of its mass.

$a = \frac{F}{m} = \frac{qE}{m}$

$\boxed{F = qE}$

① Assertion (A) is True, Reason (R) is True; Reason (R) is a correct explanation for Assertion (A).

$\boxed{a \propto \frac{1}{m}}$

[✓ ②] Assertion (A) is True, Reason (R) is True; Reason (R) is not a correct explanation for Assertion (A).

③ Assertion (A) is True, Reason (R) is False.

④ Assertion (A) is False, Reason (R) is True.

QUESTION

(Famous Type)

A vertical electric field of magnitude 4.9×10^5 N/C just prevents a water droplet of a mass 0.1 g from falling. The value of charge on the droplet will be: (Given $g = 9.8 \text{ m/s}^2$) **[JEE Mains 24 June 2022]**

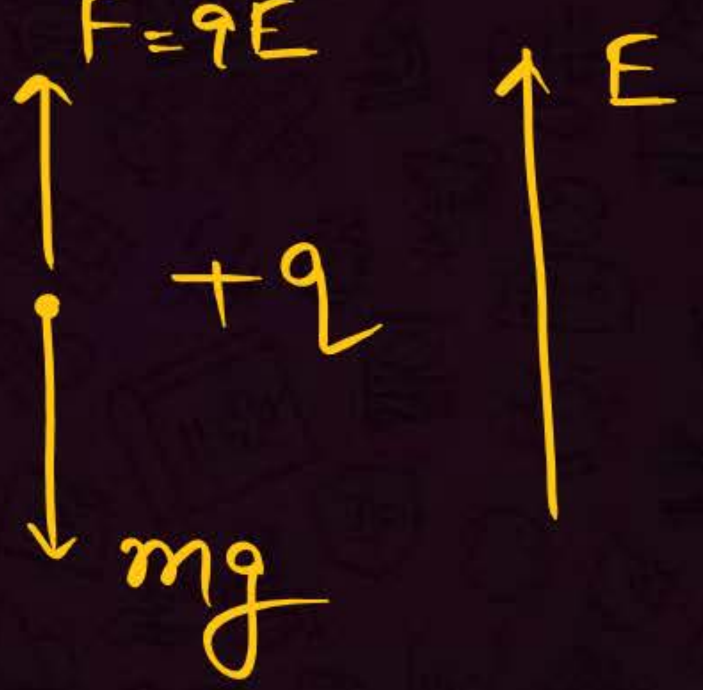
g → gram

① 1.6×10^{-9} C

② 2.0×10^{-9} C ✓

③ 3.2×10^{-9} C

④ 0.5×10^{-9} C



$m = 0.1 \text{ gm}$

$= 0.1 \times 10^{-3} \text{ kg}$

$= 10^{-4} \text{ kg}$

Balance ✓

$$\boxed{qE = mg}$$

$$q = \frac{mg}{E} = \frac{10^{-4} \times \overset{2}{\cancel{9.8}}}{\cancel{4.9} \times 10^5}$$

$$= 2 \times 10^{-9} \text{ C}$$

Motion of charge particle in Electric Field

1. Charge particle moves along the Electric Field

$$+q \begin{array}{l} \xrightarrow{\qquad} u \\ \xrightarrow{\qquad} E \end{array} \longrightarrow F = qE \longrightarrow ☆\ \boxed{a = \frac{qE}{m}} \dashrightarrow$$

path

st. line.

Equation of motion valid

① $v = u + at$

② $s = ut + \frac{1}{2}at^2$

③ $v^2 - u^2 = 2as$

☆ ④ $s = \left(\frac{u+v}{2}\right)t$

QUESTION

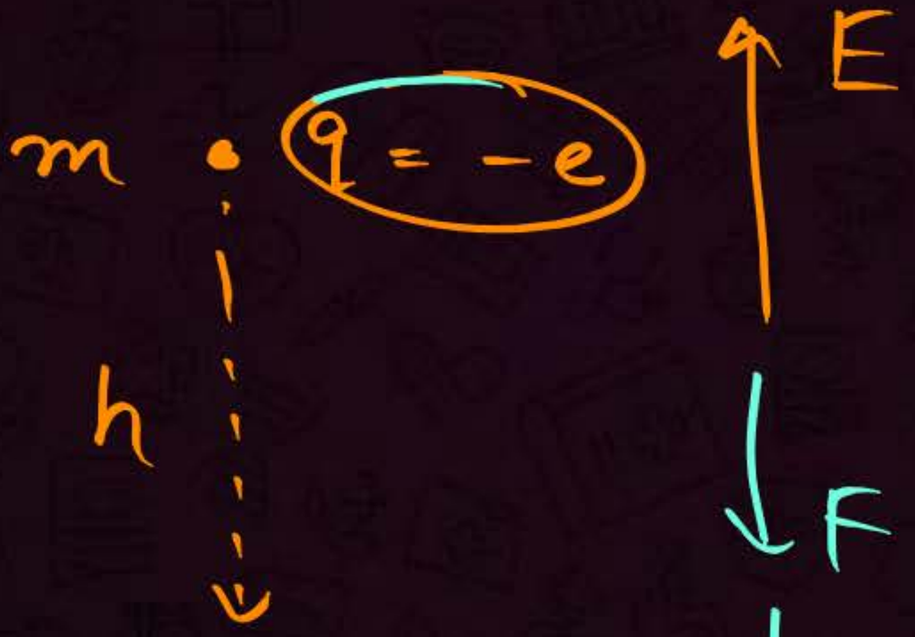
An electron of mass m, charge e falls through a distance h meter in a uniform electric field E vertically upwards. Then, time of fall is:

① $t = \sqrt{\frac{2hm}{eE}}$ ✓

② $t = \frac{2hm}{eE}$

③ $t = \sqrt{\frac{2eE}{hm}}$

④ $t = \frac{2eE}{hm}$



a

$$t=\sqrt{\frac{2h}{a}}=\sqrt{\frac{2h}{\frac{eE}{m}}}$$

$$=\sqrt{\frac{2hm}{eE}}$$

$$a=\frac{qE}{m}=\frac{eE}{m}$$

TBS

$$S = \underset{0}{ut} + \frac{1}{2}\underset{g}{a}t^2$$

$$t=\sqrt{\frac{2h}{g}}$$

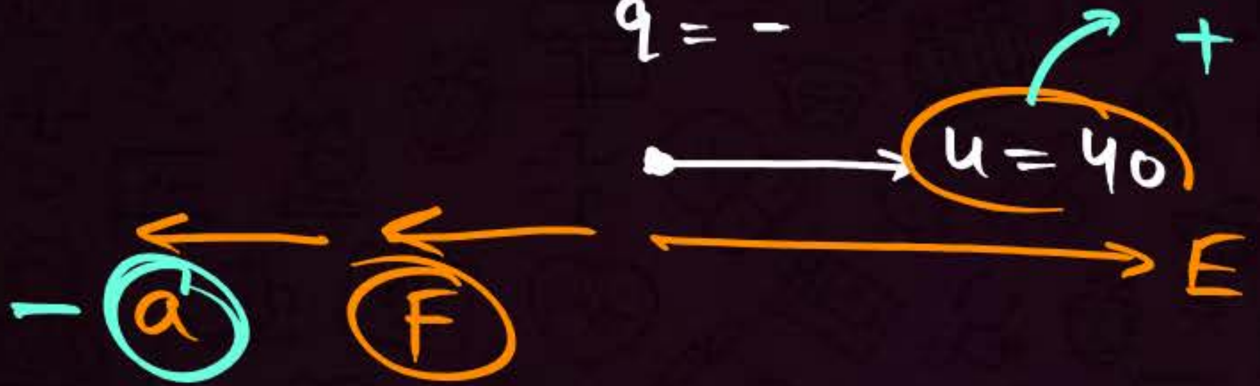
QUESTION

20×10^{-3}

A particle of mass 20g and charge –3mC moving with a speed 40 m/s enters a region of electric field 80 N/C in the same direction of the electric field. Speed of the particle after 3 seconds is:

- ~~1~~ 76 m/s
- ~~2~~ 40 m/s
- [✓ 3] 4 m/s
- 4 12 m/s

$q = -$



$$a = -\frac{qE}{m} = -\frac{3\times\cancel{10^{-3}}\times\overset{4}{\cancel{80}}}{\cancel{20}\times\cancel{10^{-3}}}$$

$$= -12$$

$$v = u + at$$

$$v = 40 + (-12)\times3$$

$$v = 4$$

QUESTION

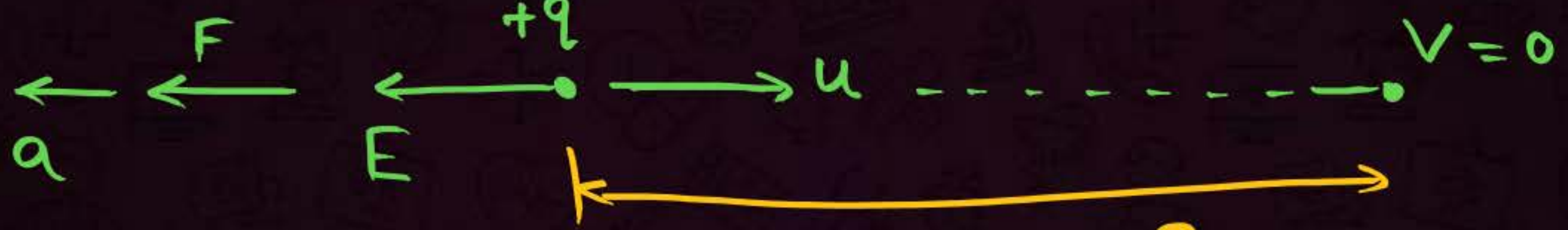
A particle of mass m and charge q is thrown at speed u against a uniform electric field E. How much distance it will travel before coming to rest?

①

②

③

④



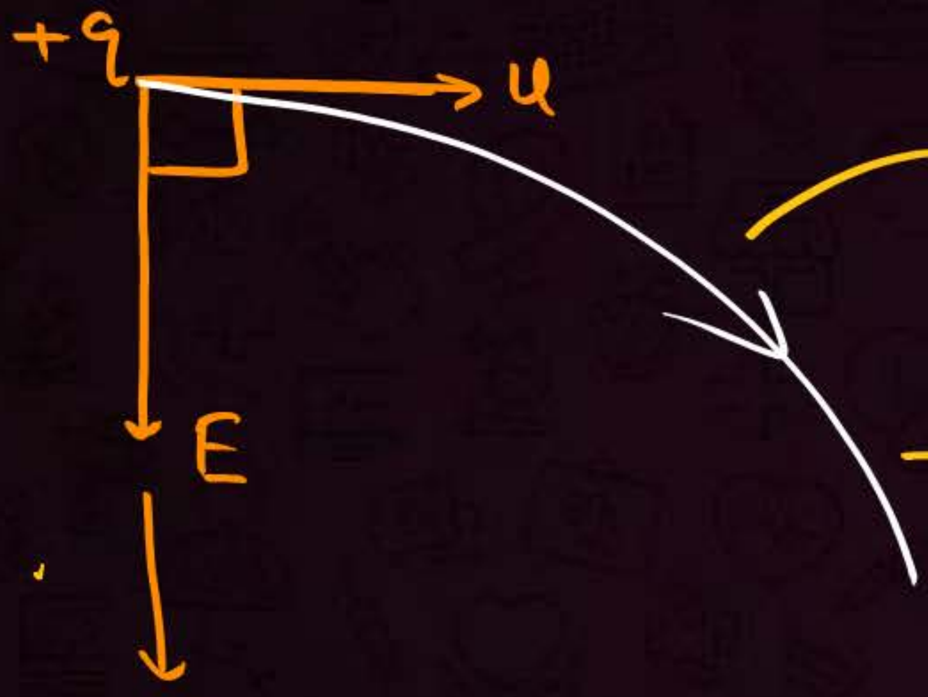
$$\boxed{S = \frac{u^2}{2a}}$$

S → Stopping dist.

$$\underset{0}{v^2} - u^2 = 2\underset{-}{a}S$$

$$S = \frac{u^2}{2 \times \frac{qE}{m}} = \frac{mu^2}{2qE}$$

2. Charge particle projected perpendicular to Electric Field



$F = qE$

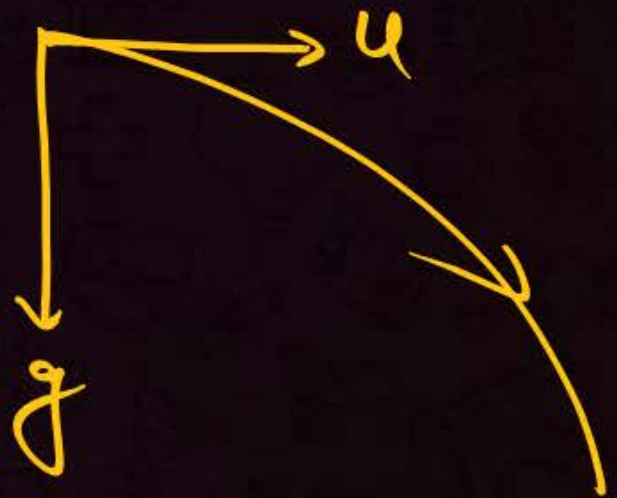
$\downarrow$

$a = \frac{qE}{m}$

→ Parabolic path

→ Deviate (Deflect) from original path

Horizontal Proj.



QUESTION

An electron is moving towards X-axis. An electric field is along Y-direction then path of electron is:

⊥cular

1. Circular
2. Elliptical
3. [✓ Parabola]
4. None of these

QUESTION

Which of the following cannot be deflected (deviated) by electric field?

└→ F ✓

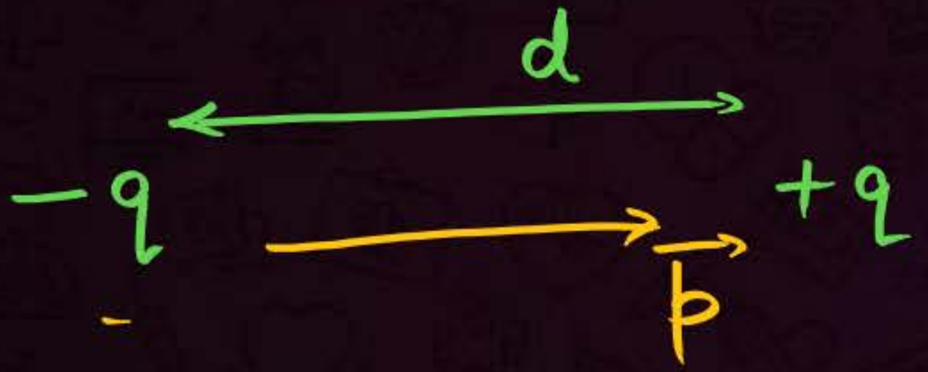
└→ q ✓

1. ✓ X-ray (Light) $q = 0$
2. β – particles (electron)
3. proton (✓)
4. α-particles (✓)

✓ γ-rays → Light → $q = 0$

ELECTRIC DIPOLE

Two equal and opposite charges separated by a small distance.



$\vec{p}$ → vector

$-q$ to $+q$

$$\boxed{\vec{p} = q \times \vec{d}}$$

* SI unit

$$\boxed{C\text{-}m}$$

QUESTION

(Famous)

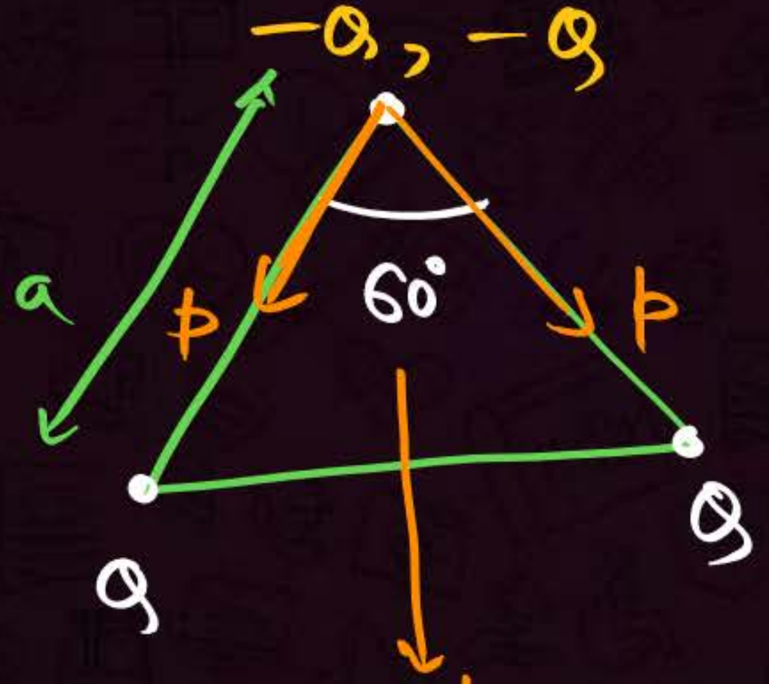
Electric charge Q, Q and $-2Q$ respectively are placed at the three corners of an equilateral triangle of side a. Magnitude of the electric dipole moment of the system

① $\sqrt{2}\,Qa$

[✓ ② $\sqrt{3}\,Qa$]

③ Qa

④ $2\,Qa$

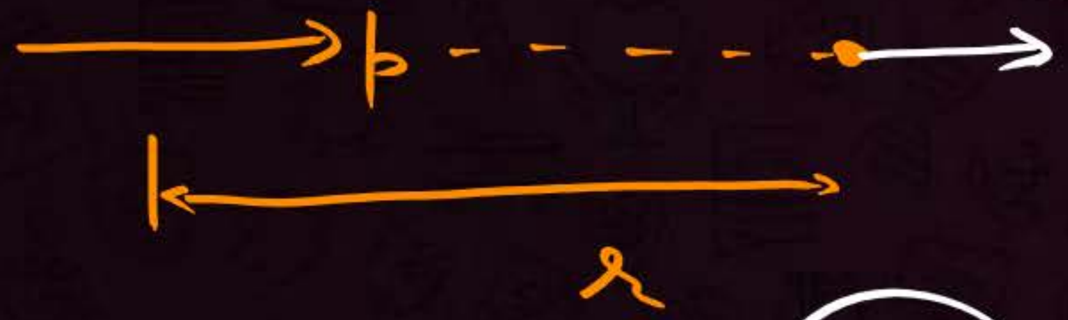


$p_{net} = \sqrt{3}\,p = \sqrt{3}\,Qa$

ELECTRIC FIELD DUE TO A DIPOLE

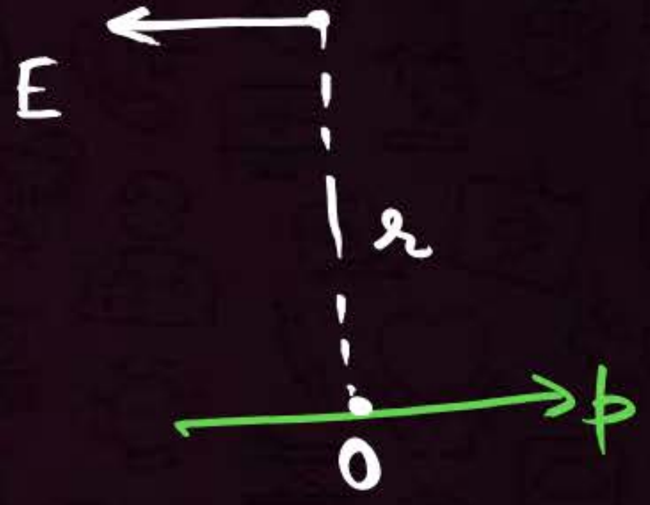
1. Axial Point

$$\boxed{\vec{E} = \frac{2k\vec{p}}{r^3}}$$



$E \propto \frac{1}{r^3}$

2. Equitorial Point



$$\boxed{\vec{E} = -\frac{k\vec{p}}{r^3}}$$

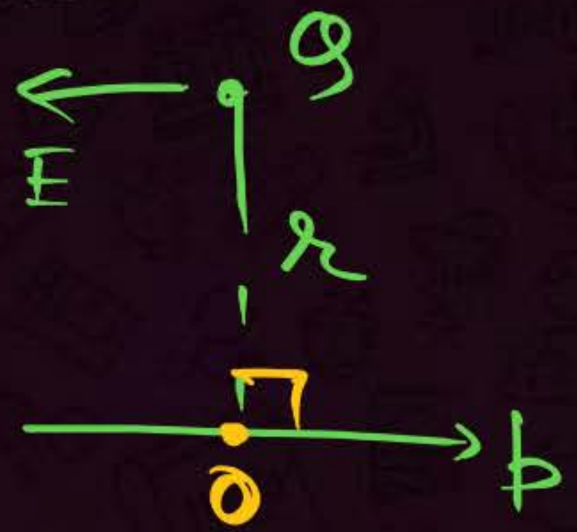
→ 2020 NEET

PYQ

QUESTION

equitorial.

A point Q lies on the perpendicular bisector of an electrical dipole of dipole moment p. If the distance of Q from the dipole is r (much larger than the size of the dipole), then electric field at Q is proportional to **(1998)**



$$E = \frac{kp}{r^3} = kp\,r^{-3}$$

$$E \propto p$$

$$E \propto r^{-3}$$

① p^{-1} and r^{-2}

② p and r^{-2}

③ p^{2} and r^{-3}

[✓ ④ p and r^{-3}]

QUESTION

Two point charges of 1 μC and –1 μC are separated by a distance of 100 Å. A point P is at a distance of 10 cm from the midpoint and on the perpendicular bisector of the line joining the two charges. The electric field at P will be

① $9\ NC^{-1}$

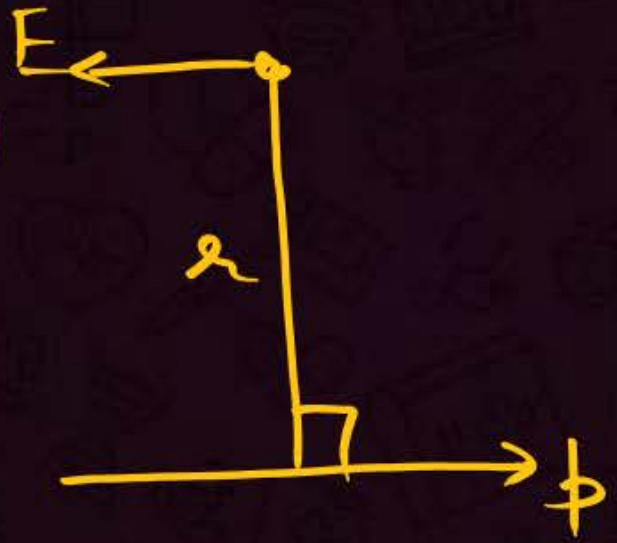
② $0.9\ NC^{-1}$

③ $90\ NC^{-1}$

[✓ ④] $0.09\ NC^{-1}$

$r = 10 \times 10^{-2} m$

$= 10^{-1} m$



$$E = \frac{kp}{r^3} = \frac{9 \times 10^9 \times 10^{-14}}{(10^{-1})^3}$$

$$p = q \times d = 10^{-6} \times (100) \times 10^{-10}$$

$$= 10^{-14}$$

QUESTION

TBS $\frac{1}{2^3} = \frac{1}{8}$

The electric force on a point charge situated on the axis of a short dipole is F. If the charge is shifted along the axis to double the distance, the electric force acting will be

① 4F

② F/2

③ F/4

[✓ ④ F/8]

$F = qE$

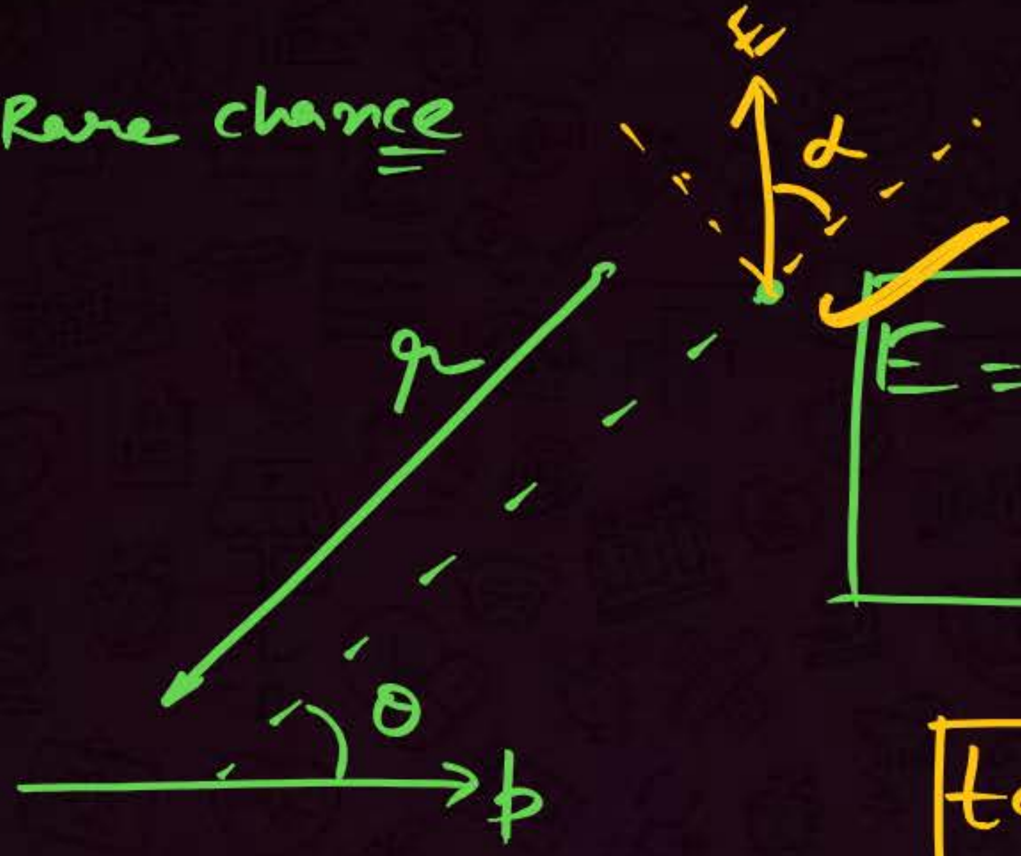
$F = q \times \frac{2kp}{r^3}$

$\boxed{F \propto \frac{1}{r^3}}$

$r \rightarrow 2r$

$F' \propto \frac{1}{(2r)^3} \propto \frac{1}{8r^3}$

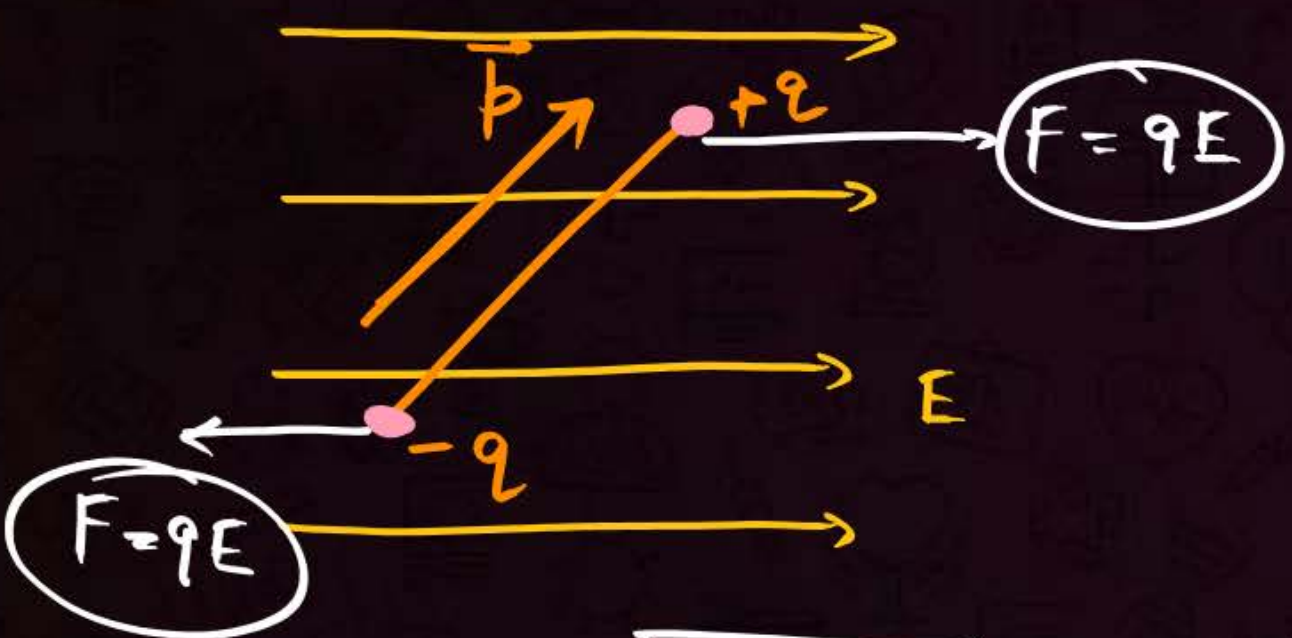
3. General Point → Rare chance



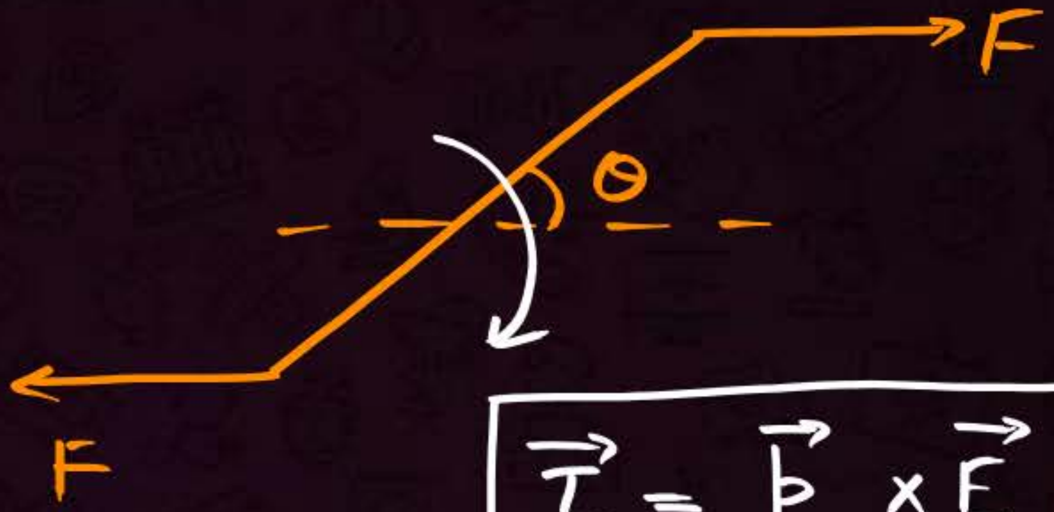
$$\boxed{E = \frac{kp}{r^3}\sqrt{1+3\cos^2\theta}}$$

$$\boxed{\tan\alpha = \frac{\tan\theta}{2}}$$

Dipole in Uniform External Electric Field



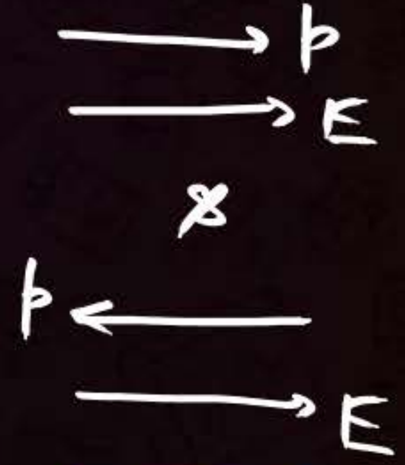
$\boxed{F_{net} = 0}$ in uniform E



$$\boxed{\vec{\tau} = \vec{p} \times \vec{E}}$$

$$\boxed{\tau = pE\sin\theta}$$

a) $\underline{\theta = 0^\circ, 180^\circ}$



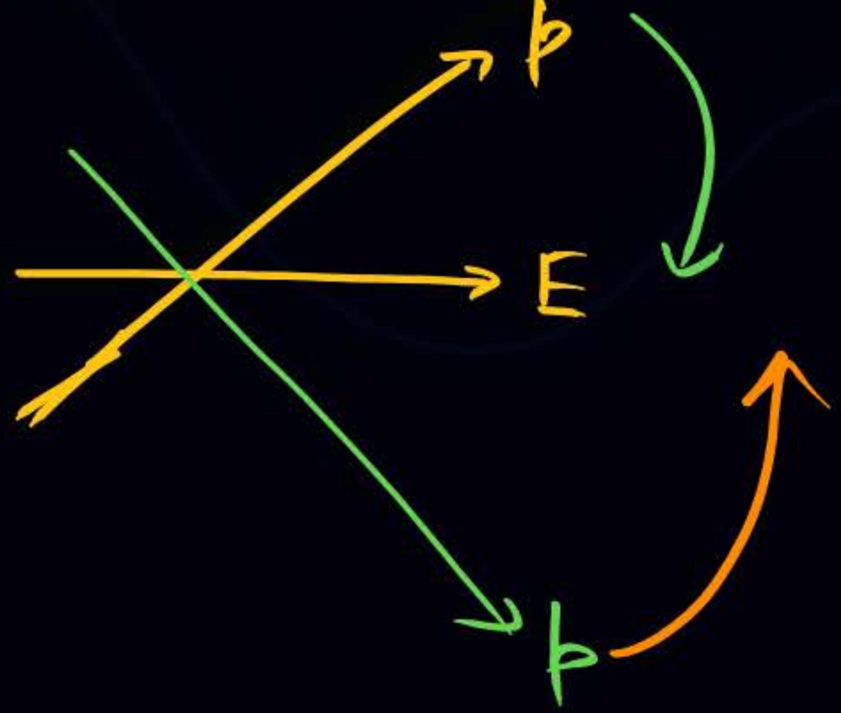
$\boxed{\tau = 0}$

↓

equilibrium

b) $\underline{\theta = 90^\circ}$

$$\boxed{\tau_{max} = pE}$$



⇒

Rare chance

oscillate ⇒ SHM

$$\boxed{T = 2\pi\sqrt{\frac{I}{pE}}}$$

Time period

I = moment of inertia.

$$T = \frac{2\pi}{\omega}$$

$$\boxed{\omega = \sqrt{\frac{pE}{I}}}$$

QUESTION

Two charges each of magnitude 0.01 C and separated by a distance of 0.4 mm constitute an electric dipole. If the dipole is placed in an uniform electric field '$\vec{E}$' of 10 dyne/C making 30° angle with $\vec{E}$, the magnitude of torque acting on dipole is:

[13 April 2023 (I)]

1. 4.0×10^{-10} Nm
2. [✓ 2.0×10^{-10} Nm]
3. 1.0×10^{-8} Nm
4. 1.5×10^{-9} Nm

$$\frac{0.4}{2} = 0.2$$

$$\tau = pE\sin\theta$$

$$p = q \times d = 0.01 \times (0.4 \times 10^{-3}) \text{ C-m}$$

$$E = 10 \times 10^{-5} \frac{N}{C}$$

$$\sin\theta = \frac{1}{2}$$

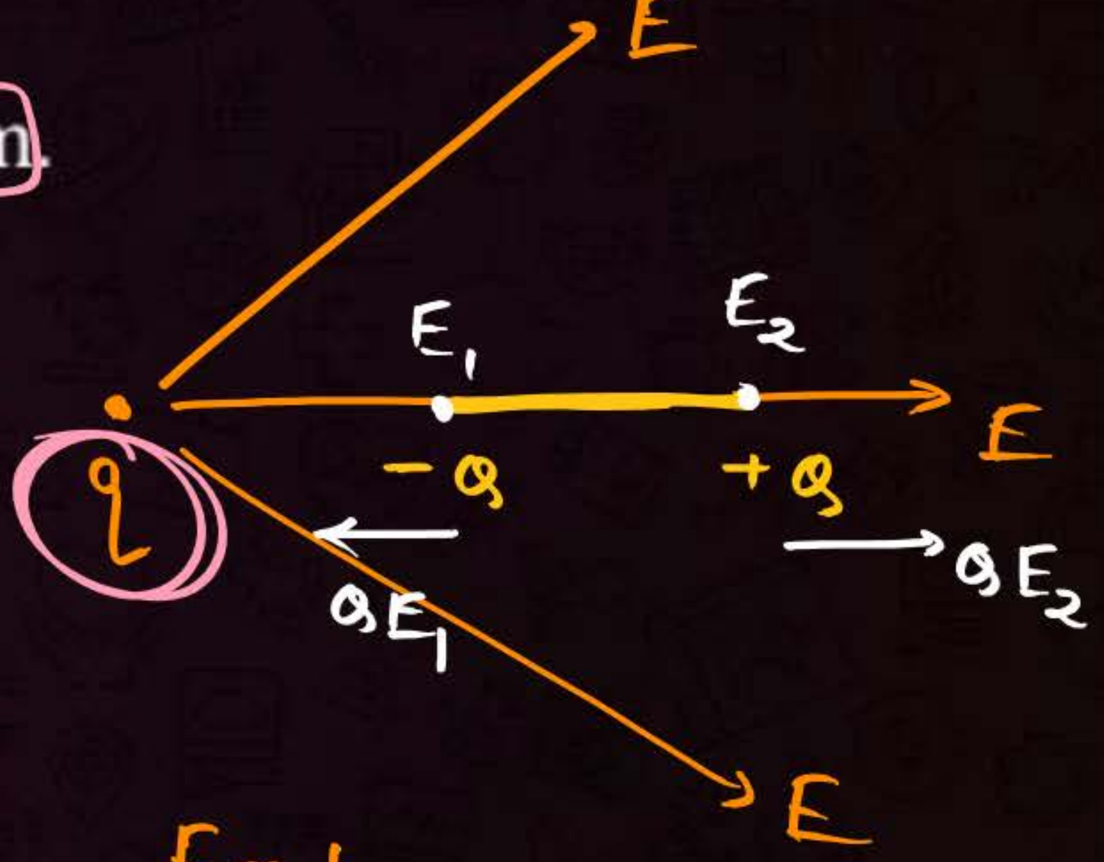
QUESTION

Conceptual

Statement-I: An electric dipole placed in the electric field of a point charge can never experience zero resultant force.

Statement-II: Electric field of a point charge is non uniform.

1. Both Statement I and Statement I are correct
2. Both statement I and Statement II are incorrect.
3. Statement I is correct and statement II incorrect.
4. Statement I is incorrect and statement II is correct.

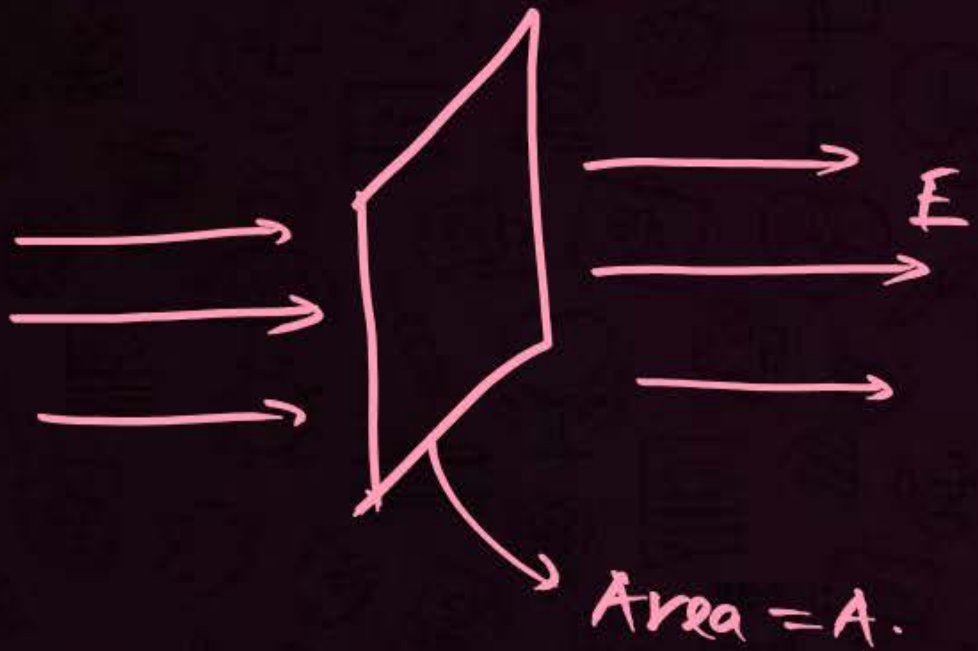


$E \propto \frac{1}{r^2}$

ELECTRIC FLUX

Measures the number of electric field lines passing through a given area.

crossing



$$\boxed{\begin{aligned}\phi &= \vec{E}\cdot\vec{A}\\ \phi &= EA\cos\theta.\end{aligned}}$$

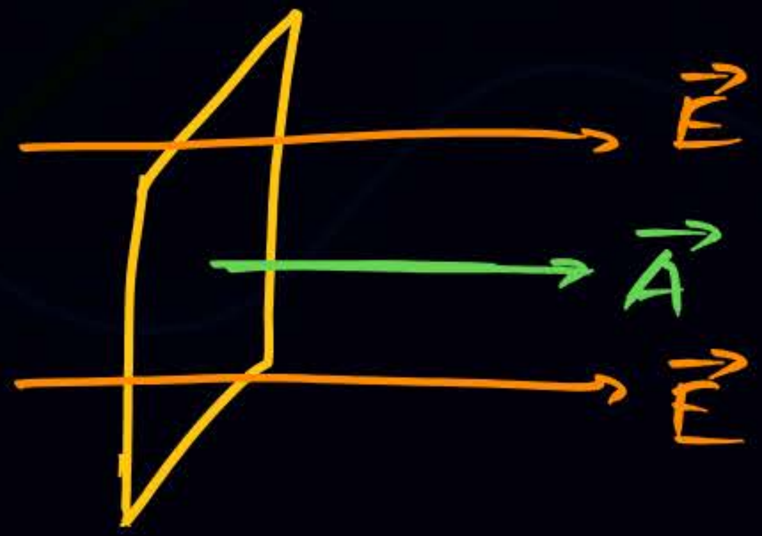
$\vec{A}$ ⇒ ⊥cular to surface

θ ⇒ angle b/w $\vec{E}$ & $\vec{A}$

SI unit $\frac{Nm^2}{C}$

Scalar

Ques

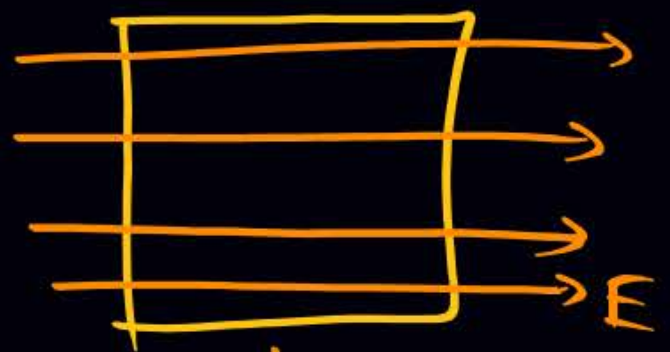


$\phi = EA\cos 0°$

$\boxed{\phi = EA}$

↳ max^m

Ques



↳ Area = A

$\boxed{\phi = 0}$

||el to surface

$\phi = EA\cos 90°$
$= 0$

xy plane $\vec{A} \Rightarrow \hat{k}$
$\vec{E} \Rightarrow \hat{i}$

QUESTION

A square surface of side L metres is in the plane of the paper. A uniform electric field $\vec{E}$ (volt/m), also in the plane of the paper. is limited only to the lower half of the square surface (see Figure). The electric flux in S.I. units associated with the surface is

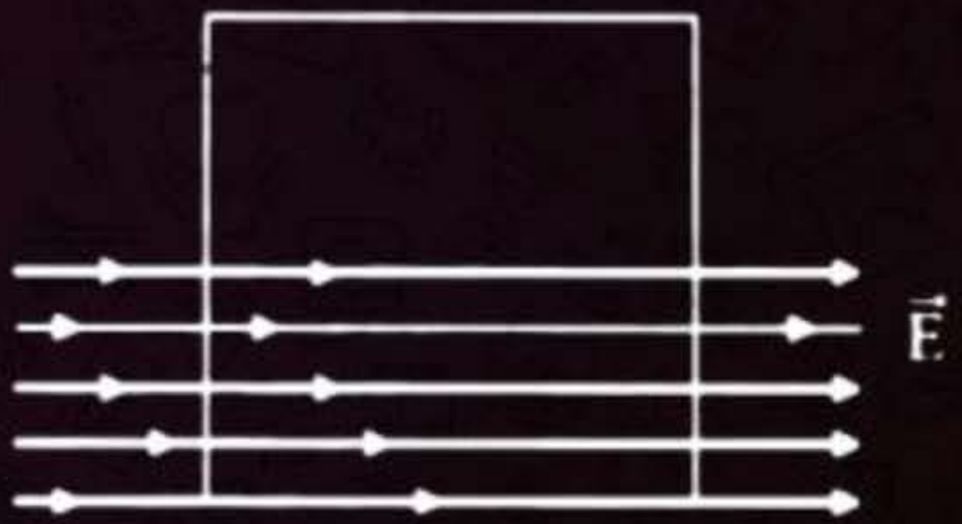
(2006)

[✓ ① zero]

② EL^2

③ $EL^2/(2\varepsilon_0)$

④ $EL^2/2$



QUESTION

Electric field in a region is uniform and is given by $\vec{E} = a\hat{\imath} + b\hat{\jmath} + c\hat{k}$. Electric flux associated with a surface of area $A = \pi R^2 \hat{\imath}$ is $+ 0\hat{j} + 0\hat{k}$

[✓ ① $a\pi R^2$]

② $3a\pi R^2$

③ $2a\pi R^2$

④ $a\pi R$

$$\Phi = \vec{E} \cdot \vec{A}$$

$$= a \times \pi R^2 + 0 + 0$$

QUESTION

If an electric field is given by $10\hat{\imath} + 3\hat{\jmath} + 4\hat{k}$ calculate the electric flux through a surface of area 10 units lying in yz plane

[✓ ① 100 units]

② 10 units

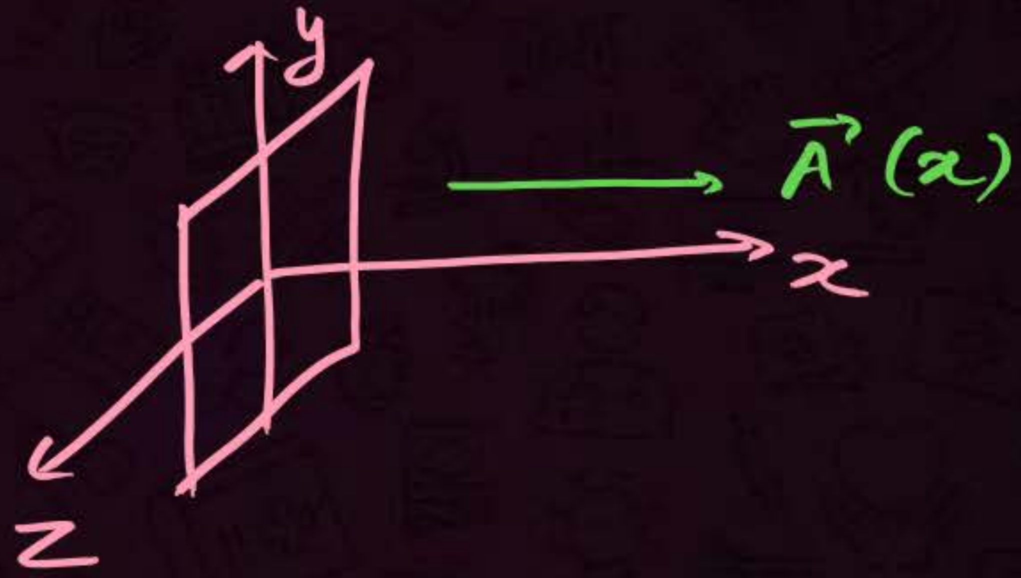
③ 30 units

④ 40 units

↳ $\vec{A} = \boxed{10\hat{i}}$

10×10

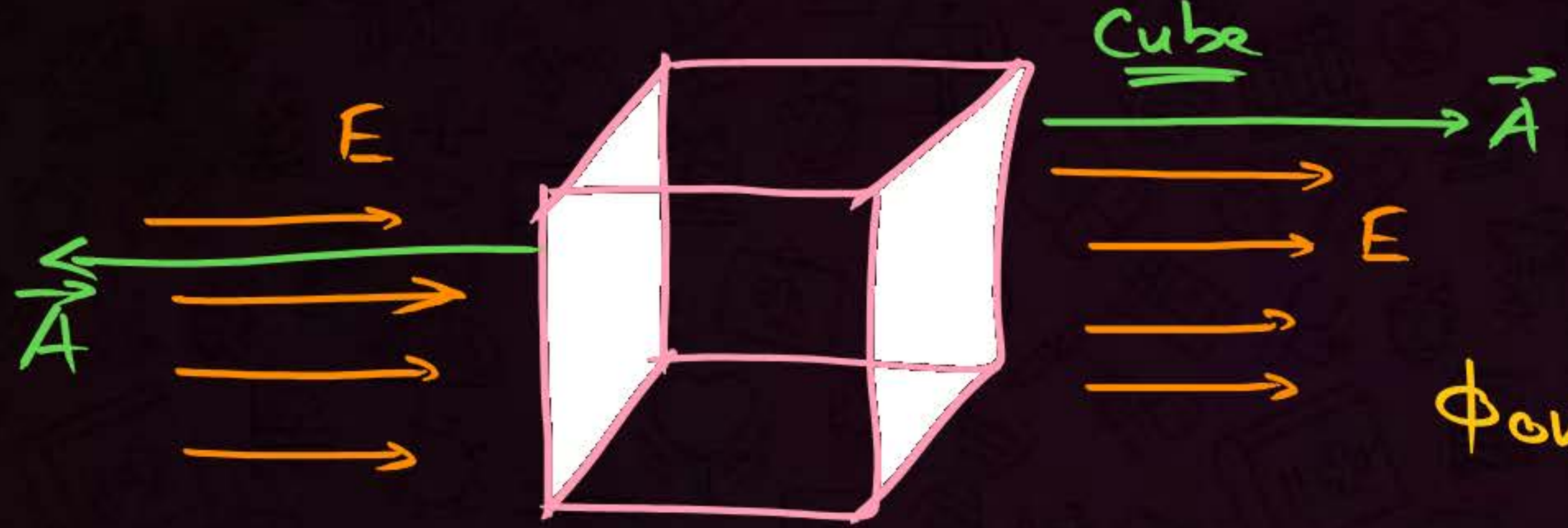
$= 100$



Flux Through a Closed Surface

↳ 3-D

Area vector always outwards



$\phi_{in} = EA\cos 180°$

$= -EA$

↳ $\boxed{-ve}$

$\phi_{out} = EA\cos 0°$

$= +EA$

↳ $\boxed{+ve}$

$\rightarrow \boxed{\phi = 0}$

$\phi_{net} = -EA + EA$

$= 0$

$\boxed{\phi_T = \phi_{net} = 0}$

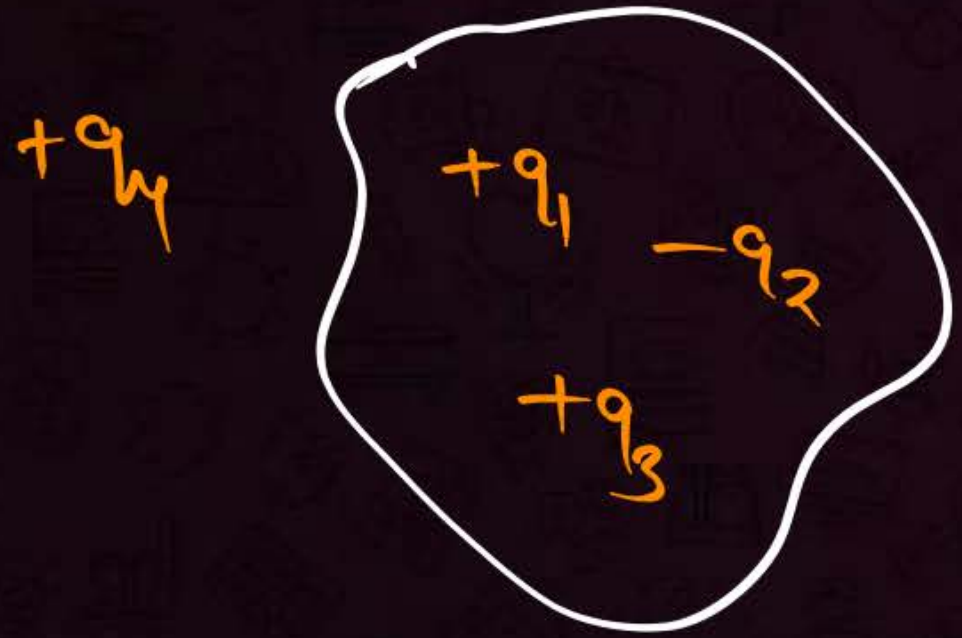
in uniform E for closed 3-D surface

GAUSS LAW

flux

$\vec{E} \cdot d\vec{A}$

The surface integral of electric field over a closed surface is equal to the charge enclosed by the surface divided by 'epsilon not'.



$$\boxed{\oint \underline{\vec{E}} \cdot d\vec{s} = \phi = \frac{q_{encl}}{\epsilon_0}}$$

* due to all charges.

inside charges

$$\frac{q_1 - q_2 + q_3}{\epsilon_0}$$

QUESTION

Total electric flux associated with unit positive charge in vacuum is

$q = 1$

$\phi = \frac{q_{encl}}{\epsilon_0} = \frac{1}{\epsilon_0}$

① $\pi\varepsilon_0$

② $1/4\pi\varepsilon_0$

[✓ ③ $1/\varepsilon_0$]

④ ε_0

QUESTION

Five electric dipoles of charge ‘q’ each are placed into the shell. What will be the amount of electric flux associated with the shell?

① $5q\varepsilon_0$

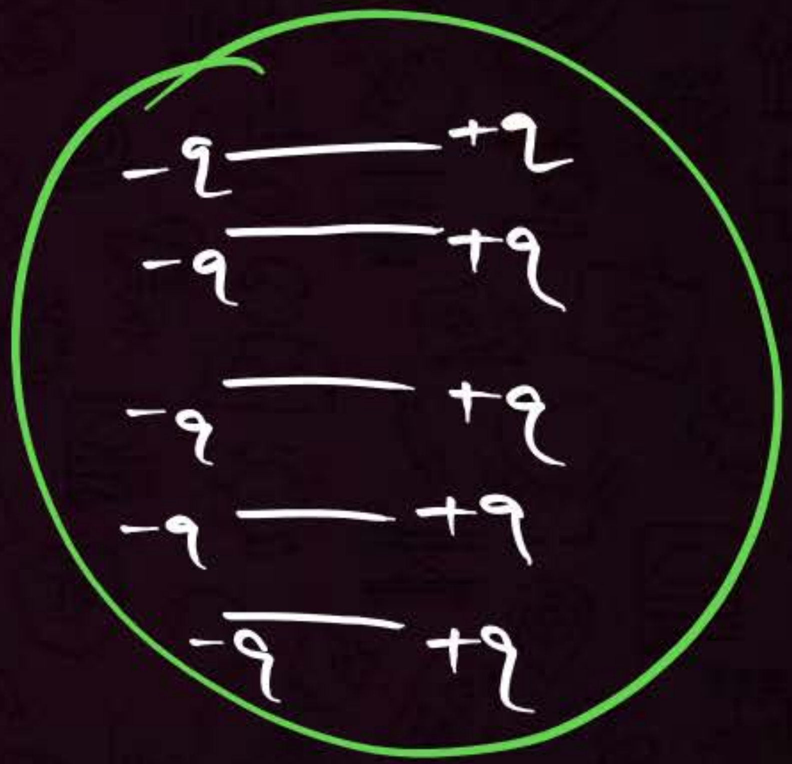
② $10q/\varepsilon_0$

[✓ ③ Zero]

④ $5q/\varepsilon_0$

$q_{encl} = 0$

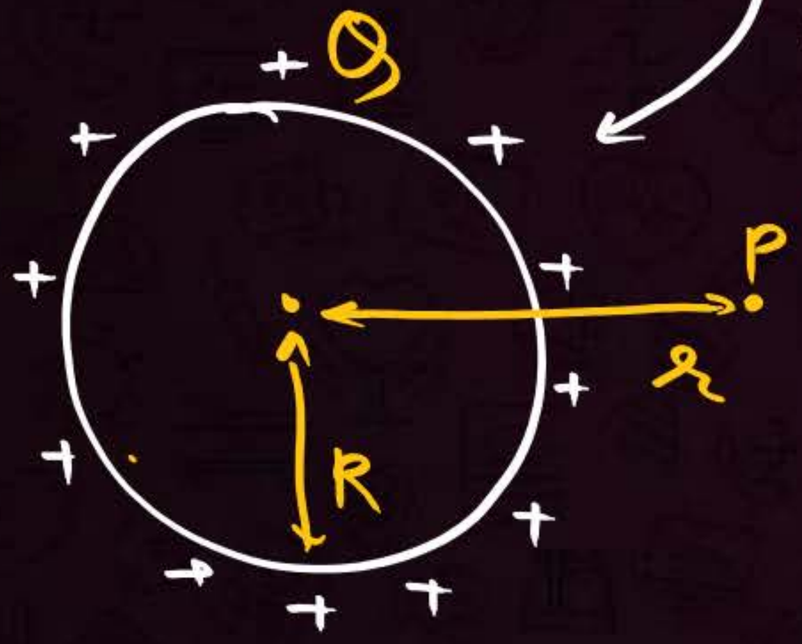
$\phi = 0$



Applications of Gauss Law

1. Hollow Sphere/ Shell and Solid Sphere (Conducting)

Charge comes outside

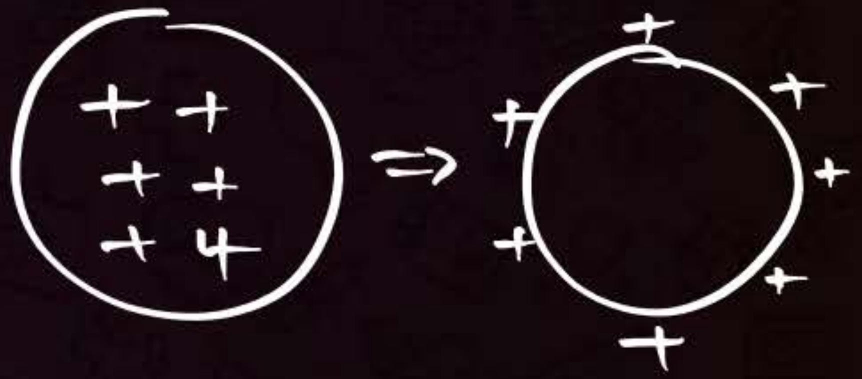


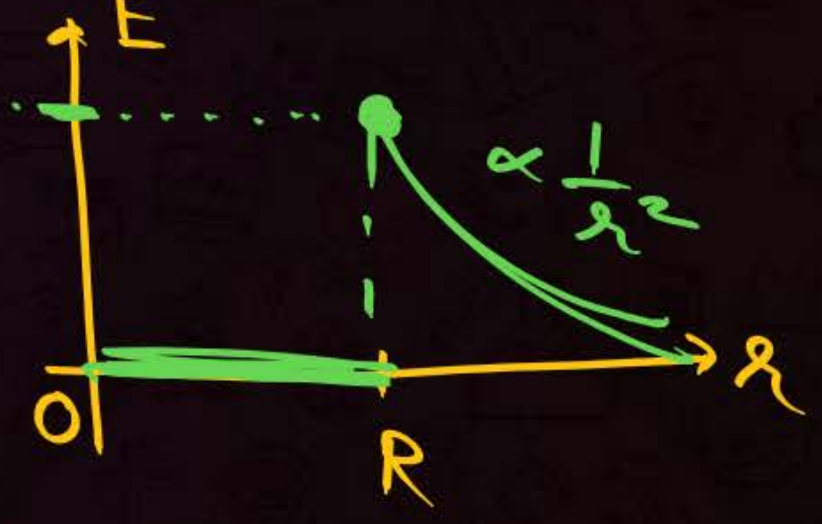
$\sigma = \frac{q}{4\pi R^2}$

$E_{in} = 0$

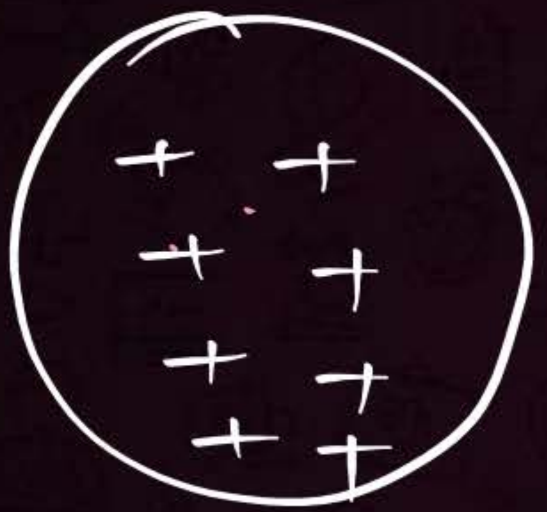
$E_{out} = \frac{kq}{r^2} \rightarrow$ pt. Charge

$E_{sur} = \frac{kq}{R^2} = \frac{\sigma}{\epsilon_0}$





2. Solid Sphere (Non Conducting)



$E_{in} \neq 0$

$$\rho = \frac{Q}{\frac{4}{3}\pi R^3}$$

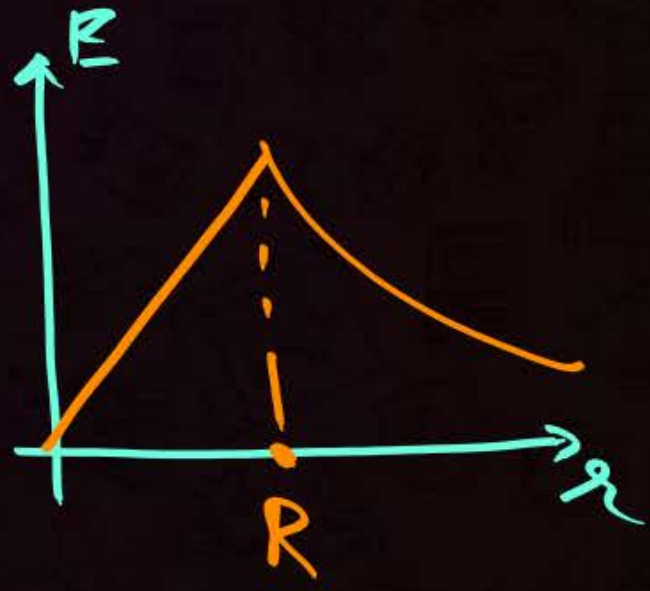
$$E_{out} = \frac{kQ}{r^2} \longrightarrow E_{out} \propto \frac{1}{r^2}$$

$$E_{sur} = \frac{kQ}{R^2}$$

$$E_{in} = \frac{kQr}{R^3} \Longrightarrow E_{in} \propto r.$$

$$E_{in} = \frac{\rho r}{3\epsilon_0}$$

$$E_{sur} = \frac{\rho R}{3\epsilon_0}$$



QUESTION

The electric field at a distance 3/2R from the centre of a charged conducting spherical shell of radius R is E. The electric field at a distance R/2 from the centre of the sphere is **[Main 2010]**

inside

[✓ ① 0]

② E

③ E/2

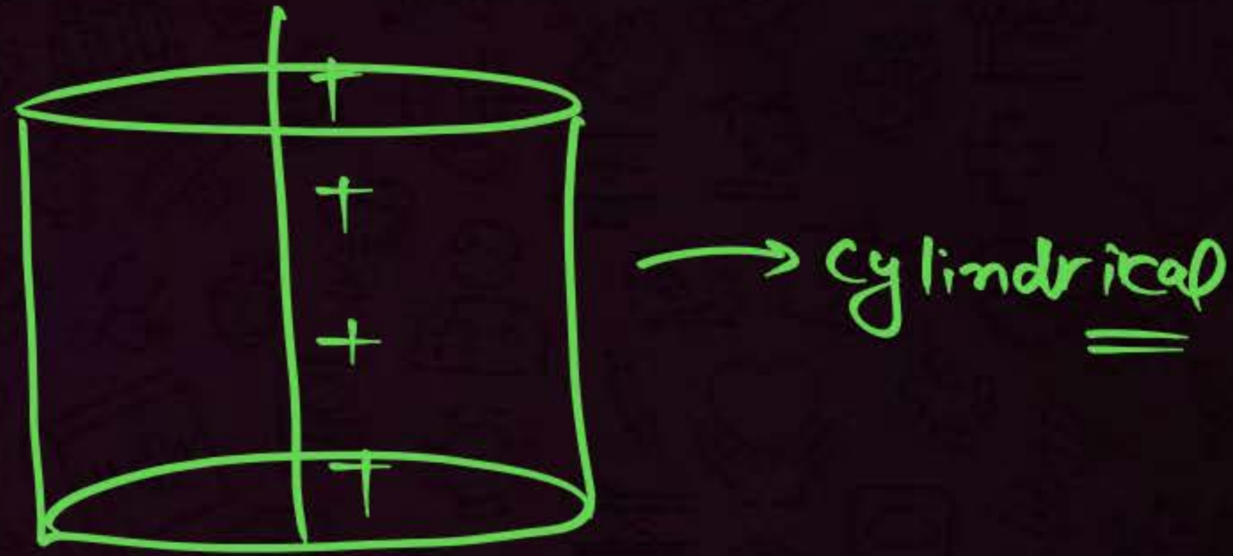
④ E/3

Pt. charge → Spherical Gaussian. Surface

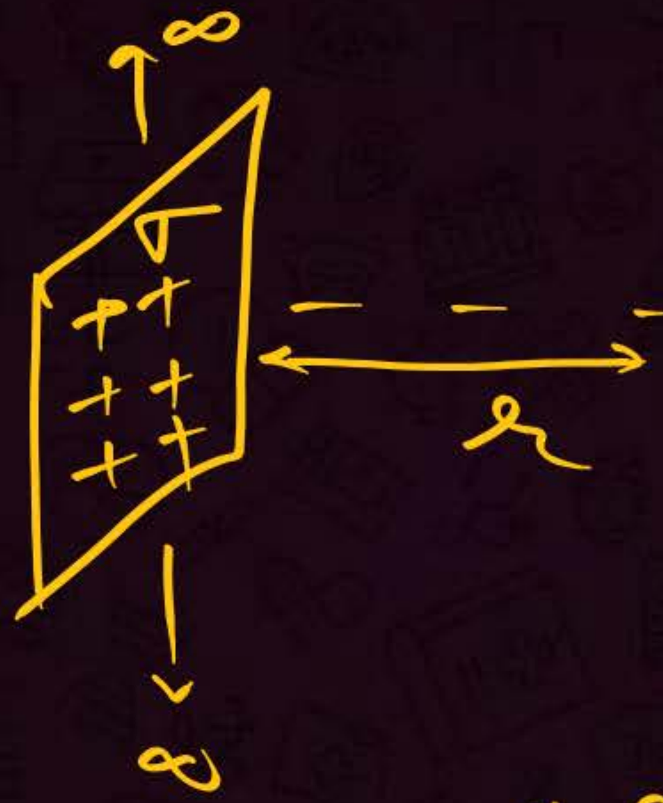
Sphere → Spherical

3. Infinite Line Charge/ Rod

→ $E = \frac{2k\lambda}{r}$



4. Infinite Non conducting Sheet



$$\boxed{E = \frac{\sigma}{2\epsilon_0}}$$

independent of r

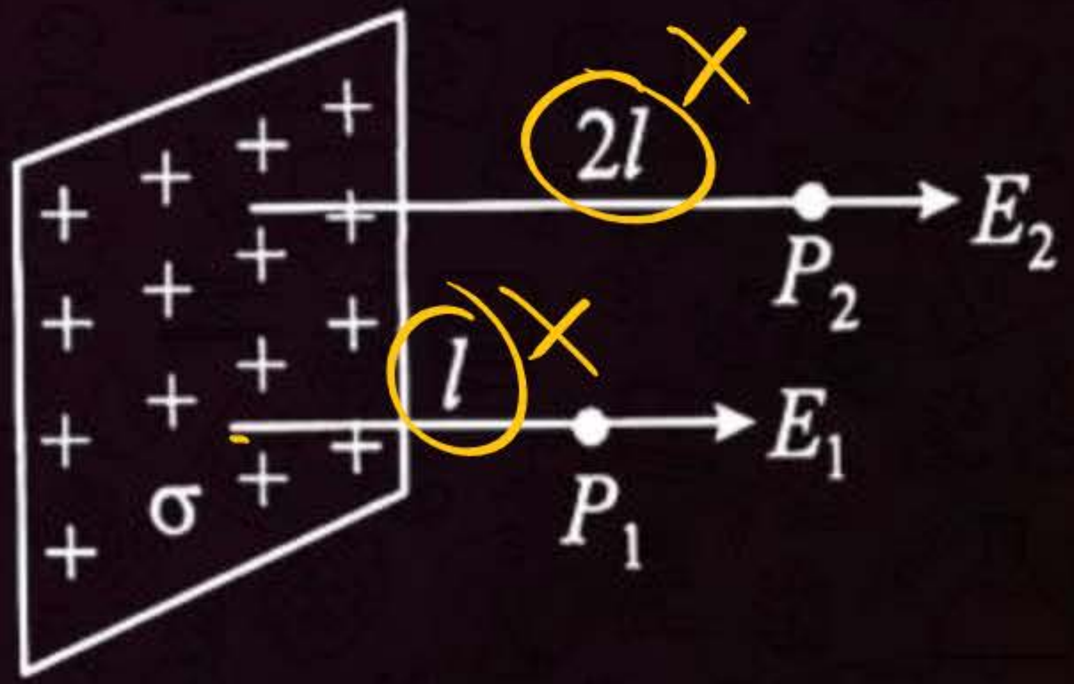
* cylindrical or cuboid

QUESTION

In the figure, a very large plane sheet of positive charge is shown. P_1 and P_2 are two points at distance l and $2l$ from the charge distribution. If σ is the surface charge density, then the magnitude of electric fields E_1 and E_2 at P_1 and P_2 respectively are

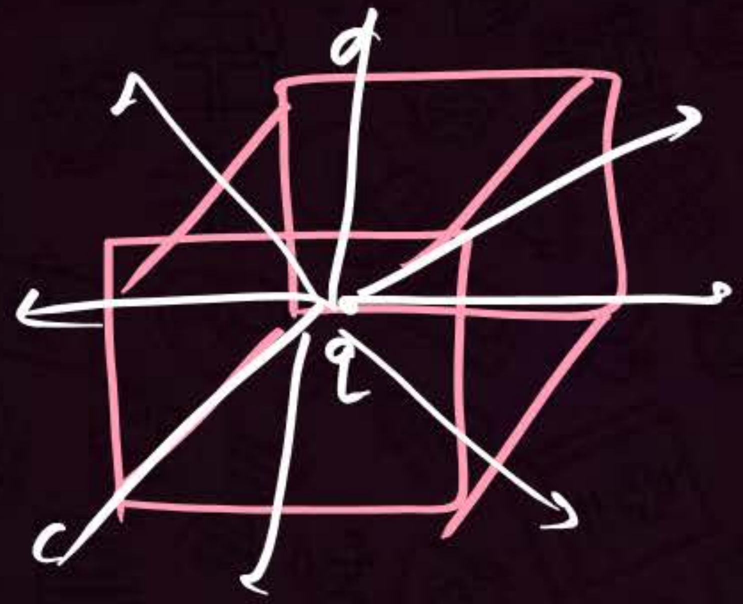
[JEE Mains 25 June 2022]

1. $E_1 = \sigma/\epsilon_0, E_2 = \sigma/2\epsilon_0$
2. $E_1 = 2\sigma/\epsilon_0, E_2 = \sigma/\epsilon_0$
3. [✓ 3] $E_1 = E_2 = \sigma/2\epsilon_0$
4. $E_1 = E_2 = \sigma/\epsilon_0$



FLUX THROUGH A CUBE

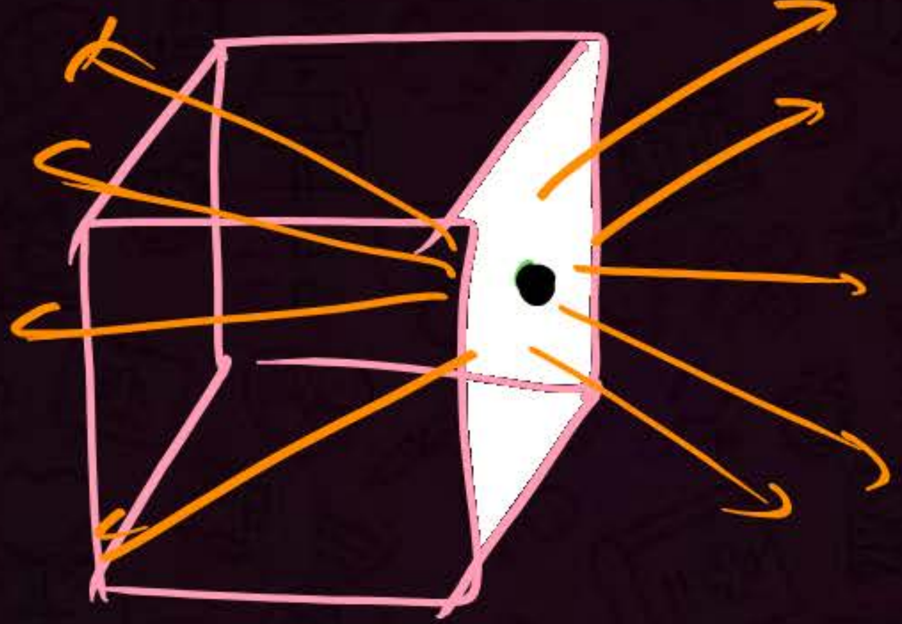
1. Charge at center of cube (Body Center)

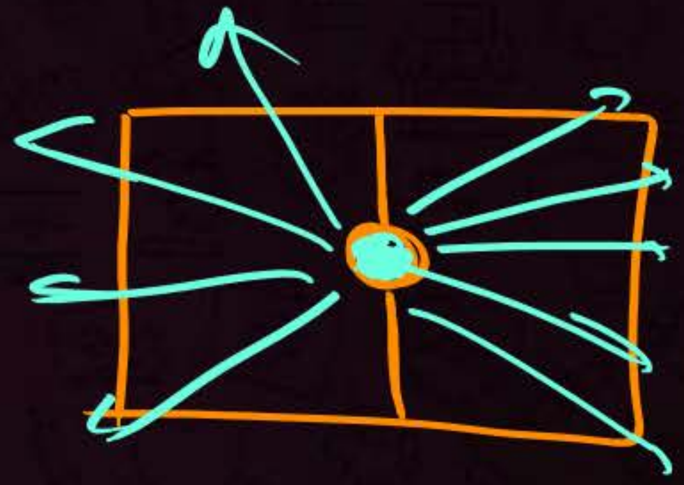


Cube $\Rightarrow \frac{q}{\epsilon_0}$

Face Each $\Rightarrow \frac{q}{6\epsilon_0}$

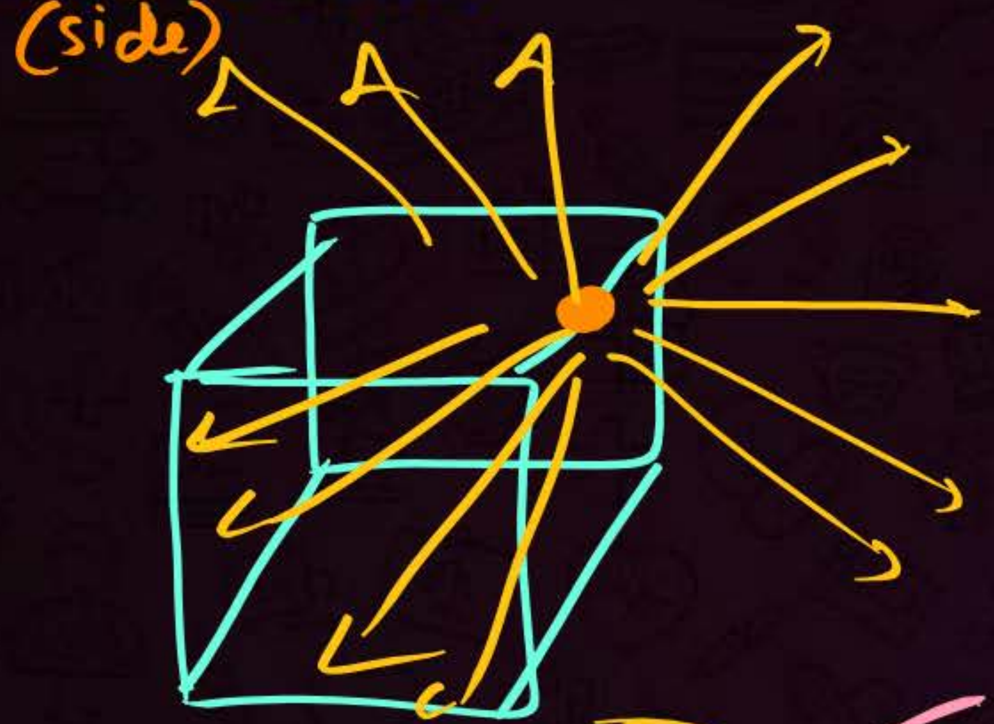
2. Charge at face center



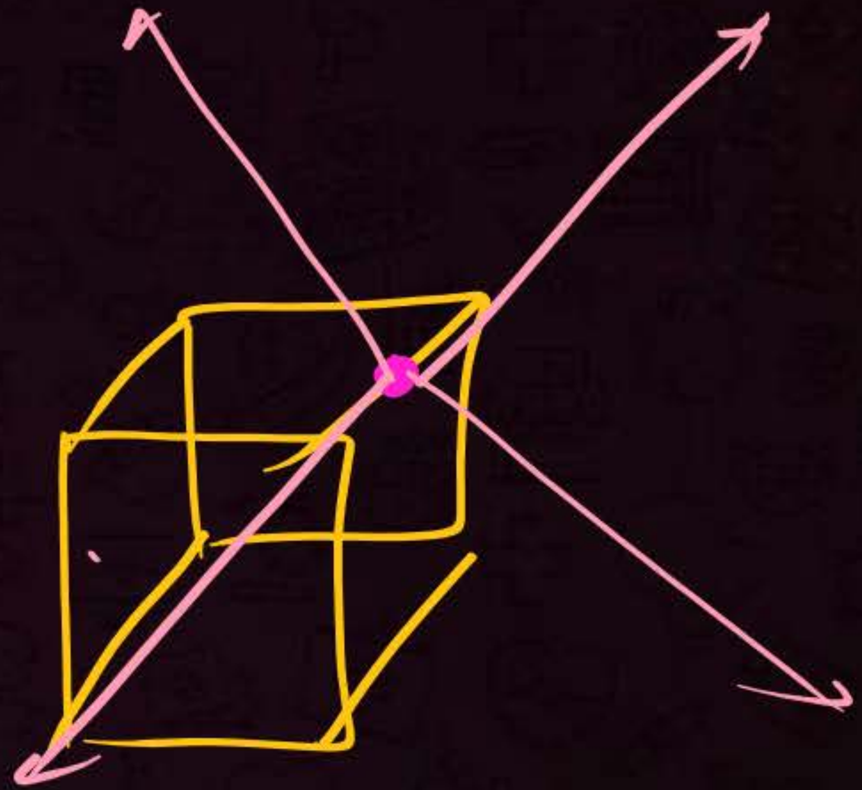


$$\underline{\underline{\text{Cube}}} \rightarrow \frac{q}{2\epsilon_0}$$

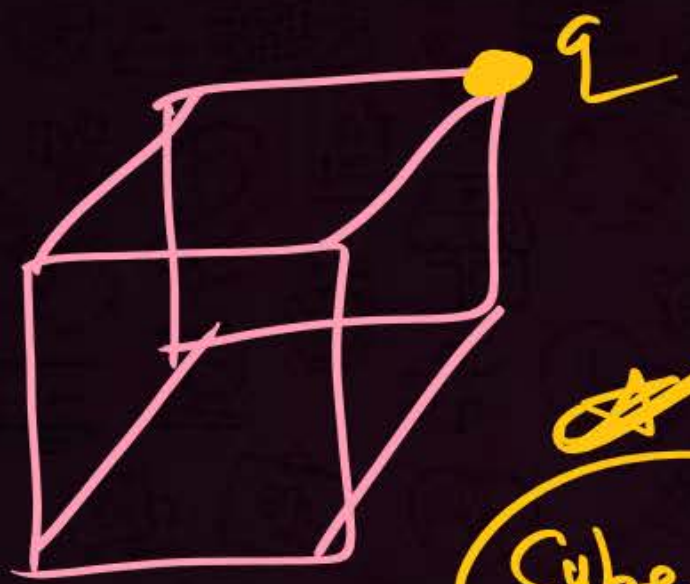
3. Charge at edge center



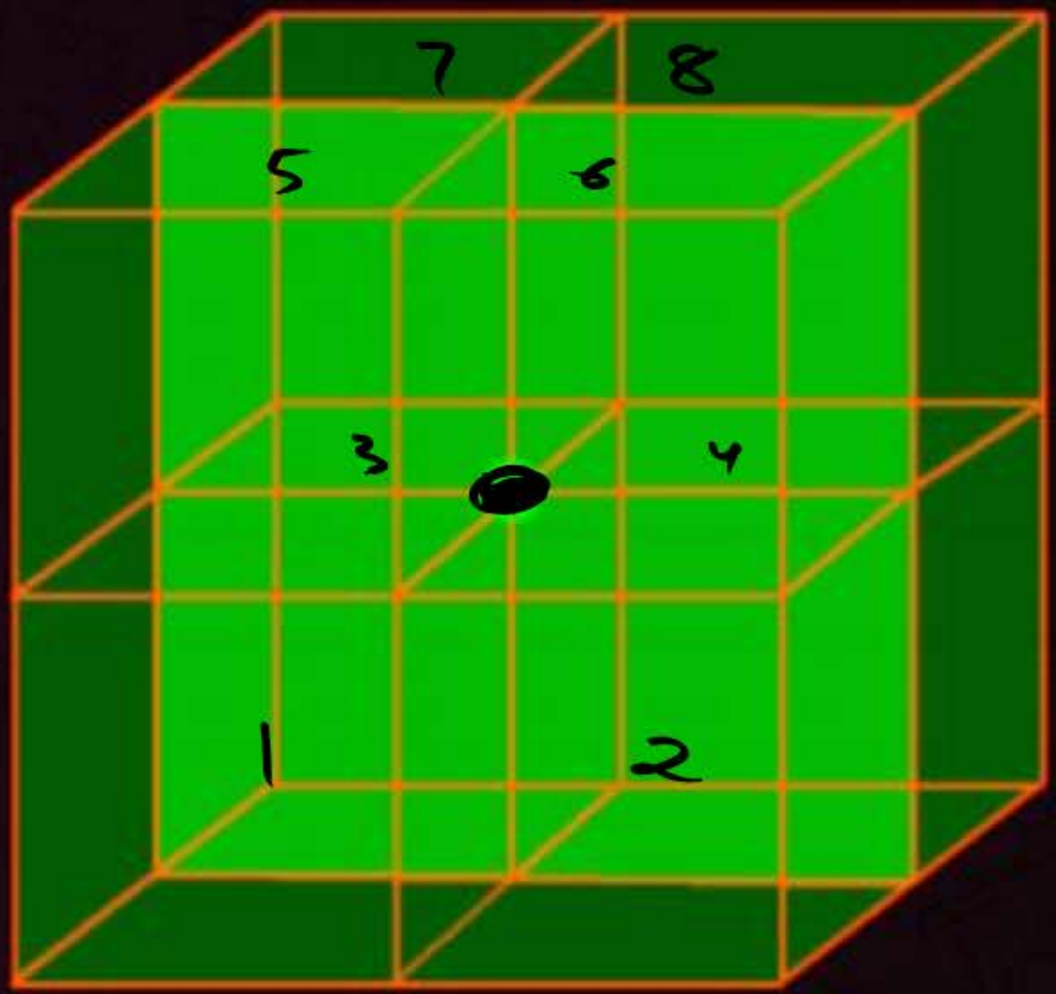
$$\boxed{\frac{q}{4\epsilon_0}} \longrightarrow \underline{\underline{\text{Cube}}}$$

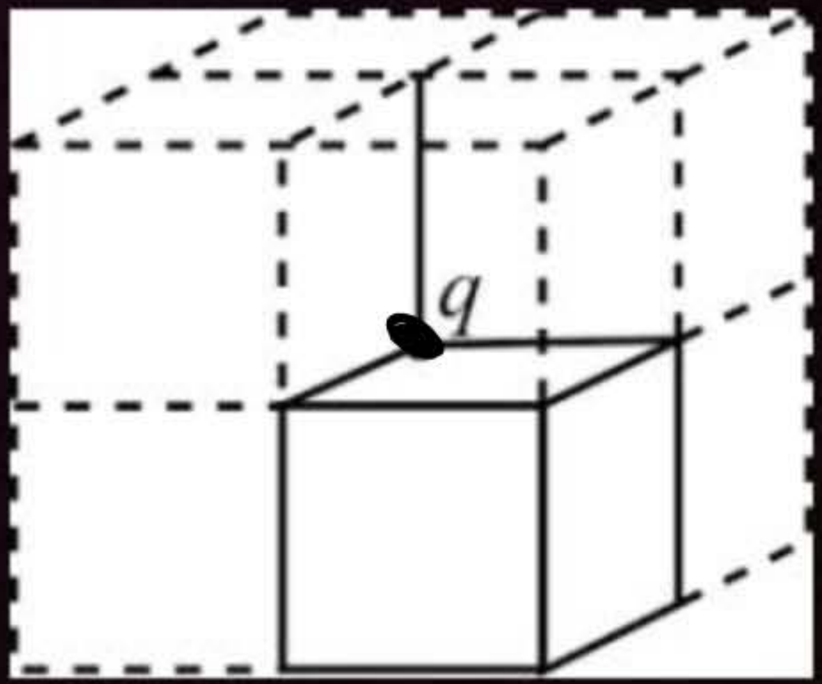


4. Charge at corner of cube



Cube ⇒ $\frac{q}{8\epsilon_0}$





QUESTION

A charge Q is situated at the corner of a cube, the electric flux passed through all the six faces of the cube is [2000]

① $\frac{Q}{6\varepsilon_0}$

[✓ ② $\frac{Q}{8\varepsilon_0}$]

③ $\frac{Q}{\varepsilon_0}$

④ $\frac{Q}{2\varepsilon_0}$

QUESTION

A charge Q μC is placed at the centre of a cube, the flux coming out from any one of the faces will be (in SI unit) **[2023 Manipur]**

[✓ ①] $\frac{Q}{6\varepsilon_0} \times 10^{-6}$

② $\frac{Q}{6\varepsilon_0} \times 10^{-3}$

③ $\frac{Q}{24\varepsilon_0}$

④ $\frac{Q}{8\varepsilon_0}$


AAE BAND KAR!
BAND KAR!

✱ TBS Capsule ① ✱

- Isolated system → charge conserved
- charge → invariant

  mass → variant

- mass Bina Charge ✓

  Charge Bina Mass ✗

- Quantization ⇒ $\boxed{q = \pm ne}$

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

- Charge less than e not possible. eg: $1.6 \times 10^{-21}\,C$
- Specific charge = $\frac{q}{m}$

- SI unit

  ⇒ C

- cgs unit

  ⇒ stat-C

  ⇒ esu

  ⇒ franklin

$\boxed{1C = 3\times10^{9}\ \text{stat-C}}$

Methods of charging

① **Rubbing** → Insulators

Glass Rod $\xrightarrow{e^-}$ Silk (GS)

Fur $\xrightarrow{e^-}$ Ebonite rod (FE)

② **Conduction** → Conductors

- One body must be charged
- Identical bodies → $\boxed{q = \frac{\text{Total Charge}}{\text{No. of Bodies}}}$

  ↓

  charge equally divided

③ **Induction** → charges redistribution

Temporary effect

- Repulsion → sure Test of electrification

GLE

↓

Rough Estimation Charge

TBS Capsule ②

* Coulomb's law

- $F = k\frac{q_1 q_2}{r^2} = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2}$

(vacuum | air)

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

* $\boxed{F' = \frac{F}{\epsilon_r} = \frac{F}{K}}$ $\epsilon_r = \frac{\epsilon}{\epsilon_0}$

- K=1 vacuum
  K≃1 air
  K>1 medium
  K→∞ conductor.

- $q_1 q_2 > 0 \Rightarrow$ repel
  $q_1 q_2 < 0 \Rightarrow$ attract
- pt. charges
- conservative
- Newton 3rd law
- $F_e >> F_g$
- TBS → Max^m force of repulsion.

⇓

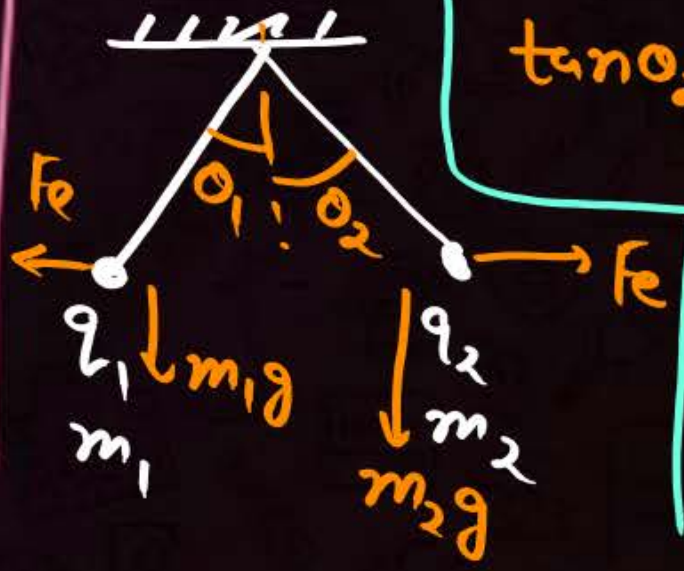
Total q equally divided

- Vector form

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

$$\vec{F} = \frac{k q_1 q_2}{r^3} \vec{r}$$

Pendulum



$\tan\theta_1 = \frac{F_e}{m_1 g}$

$\tan\theta_2 = \frac{F_e}{m_2 g}$

$$\frac{\tan\theta_1}{\tan\theta_2} = \frac{m_2}{m_1}$$

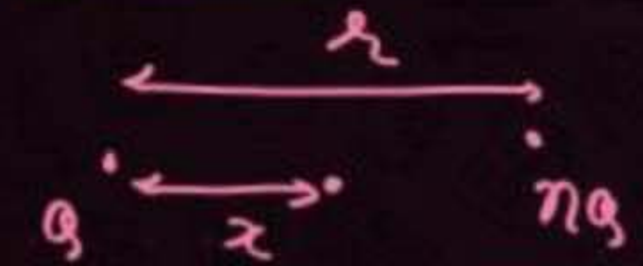
TBS Capsule ③

- Superposition - Principle

↓

3rd charge → No effect on force b/w two charges

- Similar charges



$$\boxed{x = \frac{r}{\sqrt{n}+1}}$$

↳ from Chhota charge

$$\boxed{n = \frac{\text{Bada } q}{\text{Chhota } q}}$$

- Opposite charges

$$\boxed{x = \frac{r}{\sqrt{n}-1}}$$

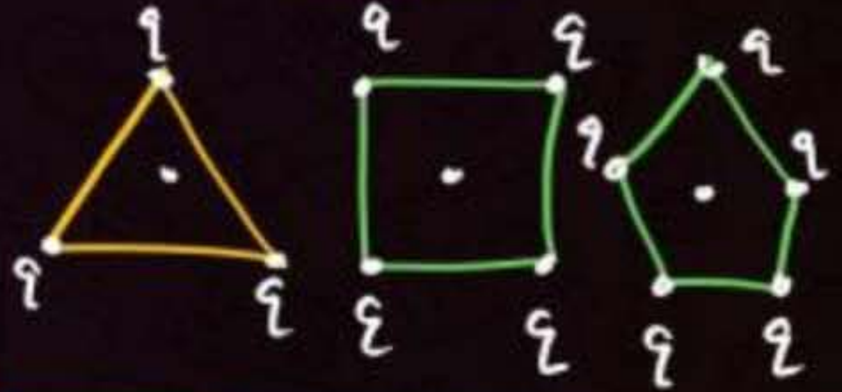
- If $F_1 = F_2 = F$

$F_{net} = \sqrt{3}F \Rightarrow \theta = 60^\circ$

$F_{net} = \sqrt{2}F \Rightarrow \theta = 90^\circ$

$F_{net} = F \Rightarrow \theta = 120^\circ$

- Regular polygon
- Charge at each vertex equal.
- $F_{net} = 0$ on charge at center.



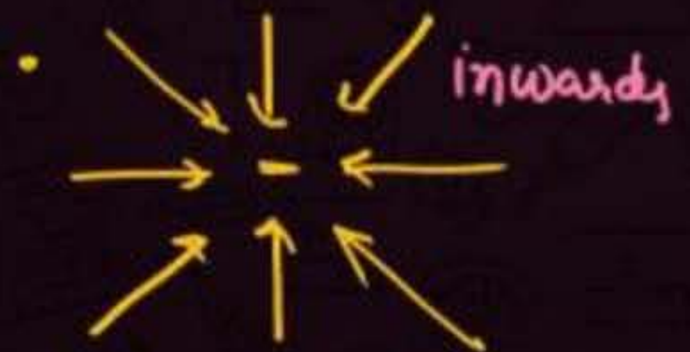
TBS Note: At same points $\boxed{E=0}$ also.

TBS Capsule ④

- $\vec{E} = \frac{\vec{F}}{q_0} = \frac{kq}{r^2}$

- SI unit ⇒ $\frac{N}{C}$ or $\frac{V}{m}$

- Pt. charge



* $\lambda = \frac{Q}{L}$, $\sigma = \frac{Q}{A}$, $\rho = \frac{Q}{V}$

① Ring ⟶ center $E = 0$

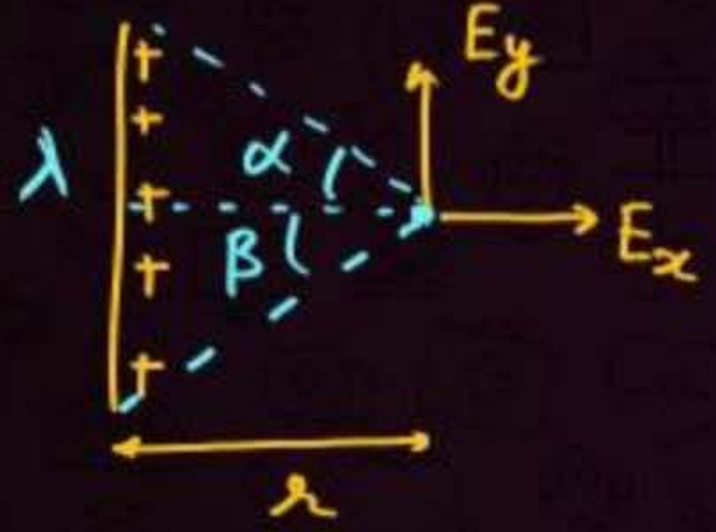
↳ axial ⇒ $E = \frac{kQx}{(x^2+R^2)^{3/2}}$.

② arc

$E = \frac{2k\lambda}{R} \sin\left(\frac{\alpha}{2}\right)$

Semicircular arc ⇒ $E = \frac{2k\lambda}{R}$.
$\alpha = 180°$

③ Rod



$$\left\{\begin{aligned} E_x &= \frac{k\lambda}{r}[\sin\alpha + \sin\beta] \\ E_y &= \frac{k\lambda}{r}[\cos\alpha - \cos\beta] \end{aligned}\right.$$

Rare chance ←

a) Infinite ⇒ $\alpha = \beta = 90^\circ$

$$E_x = \frac{2k\lambda}{r} \qquad E_y = 0$$

b) Semi-infinite rod

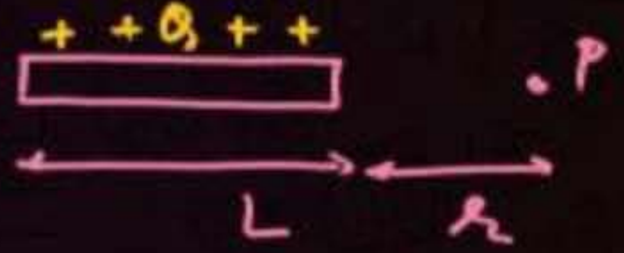
$$\alpha = 0^\circ, \beta = 90^\circ$$

ⓄⓇ

$$\alpha = 90^\circ, \beta = 0^\circ$$

$$\left.\begin{aligned} E_x &= \frac{k\lambda}{r} \\ E_y &= \frac{k\lambda}{r} \end{aligned}\right] \rightarrow E = \sqrt{2}\frac{k\lambda}{r}$$

Rod axis

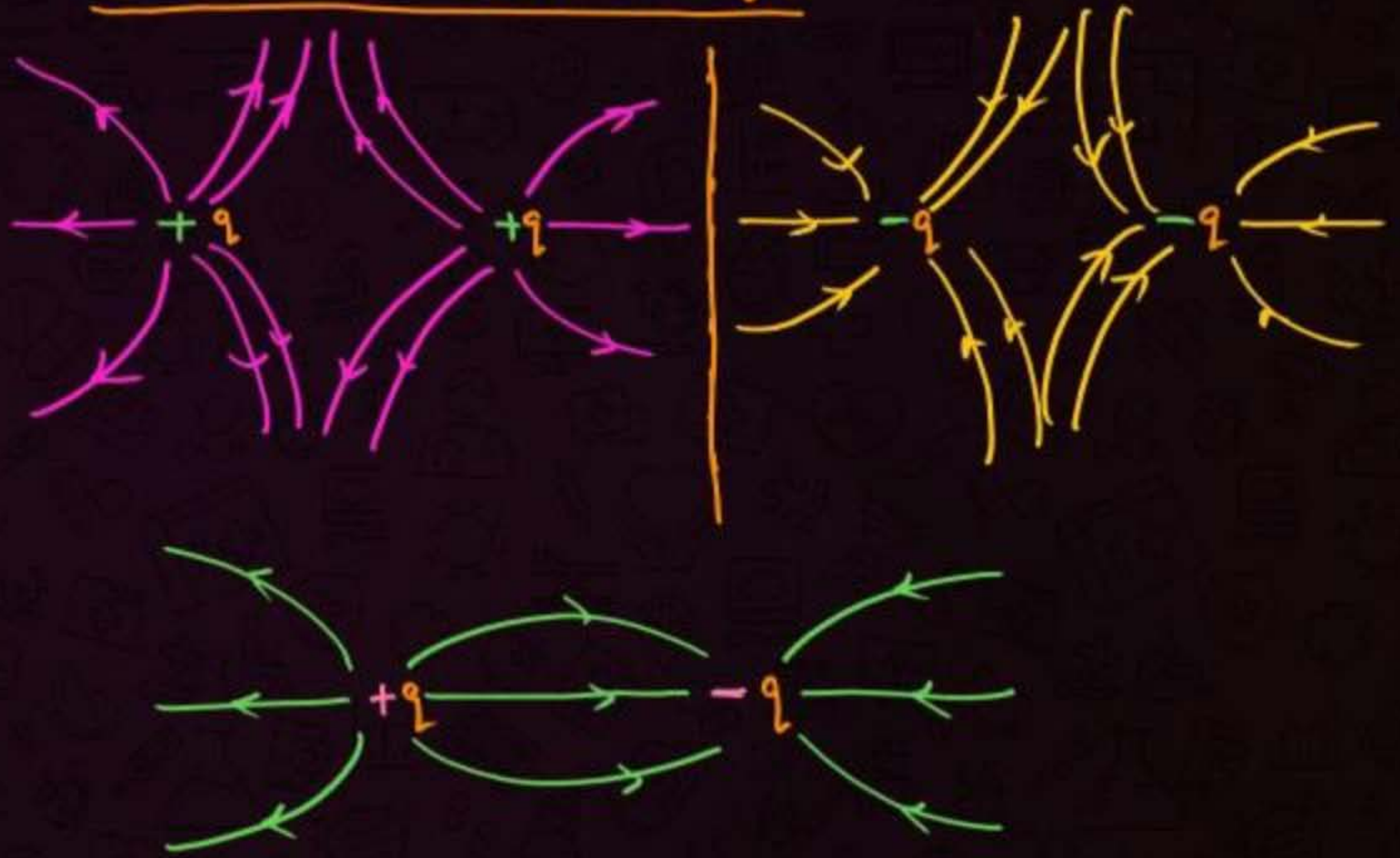


$$\boxed{E = \frac{kQ}{r(r+L)}}$$

TBS capsule ⑤

- Electric Field Lines
  or
  Electric Lines of Force
- Imaginary Lines
- Tangent → Direction
- Intersect ×
- Closed Loop ×
- Start from +q
  Terminate at −q.
- Densar Lines $\Rightarrow E\uparrow$
  Rarer Lines $\Rightarrow E\downarrow$.
- No. of Field Lines $\propto q$

E Lines due to two charges



TBS Capsule ⑥

$\longrightarrow E$

$q+ \longrightarrow F$

$\longrightarrow E$

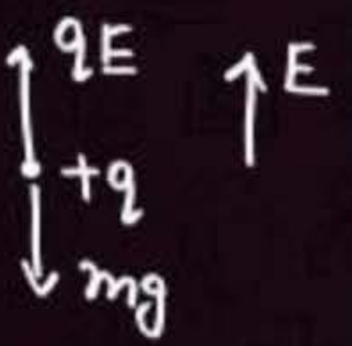
$F \longleftarrow -q$

$\longrightarrow E$

$\boxed{F = qE}$

$\boxed{a = \frac{qE}{m}}$

* Balance of charge



⇓

$\boxed{qE = mg}$

Motion in external E

a) $\overset{\longrightarrow u}{+q} \longrightarrow E \longrightarrow F \longrightarrow a = \frac{qE}{m}$.

Path Straight Line.

If a → const. ⇒

① $v = u + at$

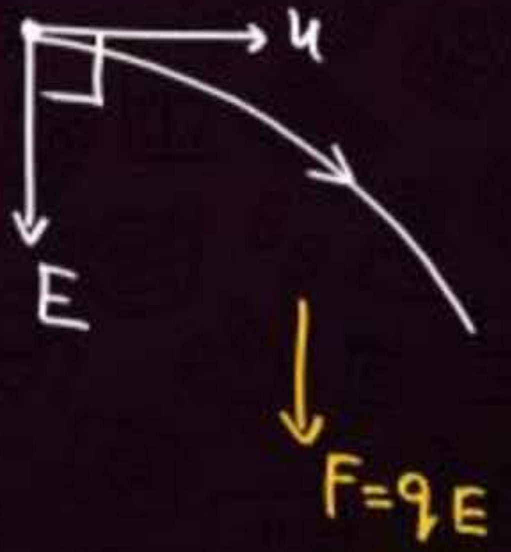
② $s = ut + \frac{1}{2}at^2$

③ $v^2 - u^2 = 2as$

④ $s = \left(\frac{u+v}{2}\right)t$

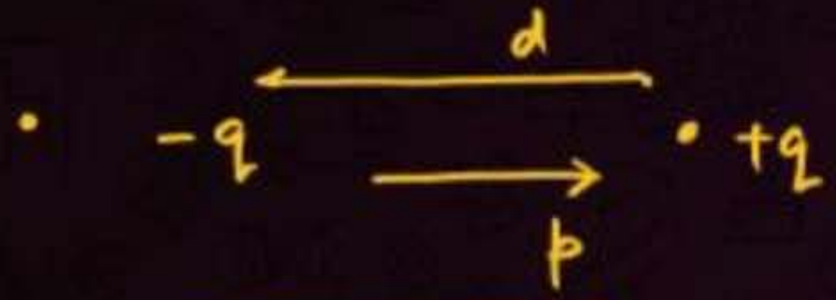
• $\boxed{t = \sqrt{\frac{2h}{a}}}$ → time of fall.

b)



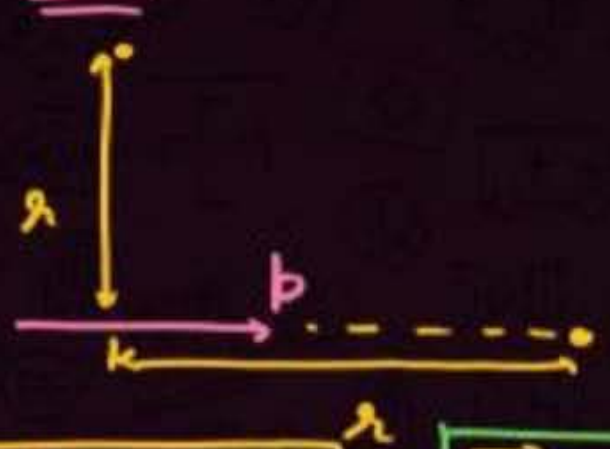
Path is parabola.

TBS capsule ⑦



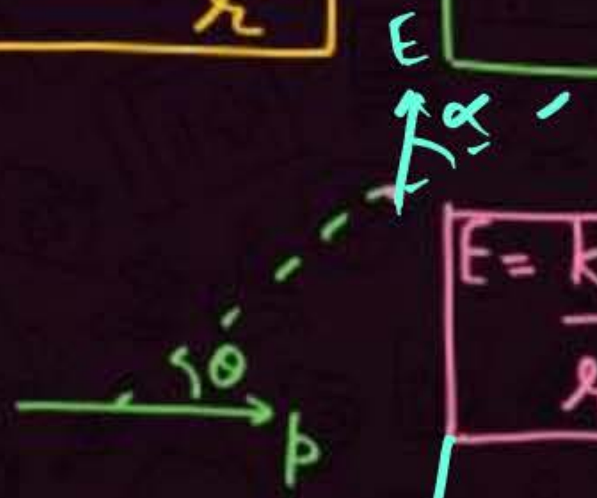
- $\boxed{\vec{p} = q \times \vec{d}}$
- -ve to +ve
- SI unit ⇒ C-m
- d → small
- $\vec{p}$ → vector quantity

Field



$$\boxed{\vec{E}_{ax} = \frac{2k\vec{p}}{r^3}}$$

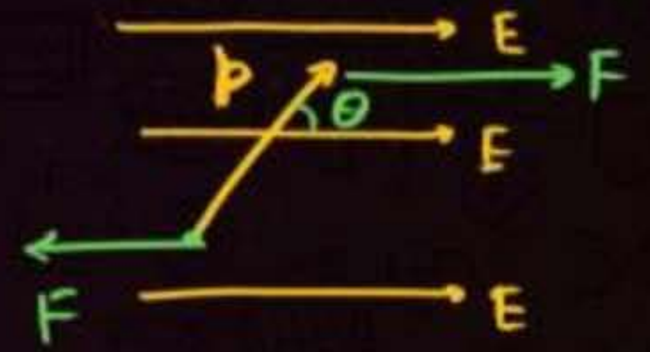
$$\boxed{\vec{E}_{eq} = -\frac{k\vec{p}}{r^3}}$$



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

$$\boxed{\tan\alpha = \frac{\tan\theta}{2}}$$

Dipole in external field



$\boxed{F_{net} = 0}$ in uniform E

- $\vec{\tau} = \vec{p} \times \vec{E}$

$\tau = pE\sin\theta$

$\tau = 0$ at $\theta = 0°, 180°$

↳ Eqb^m

$\tau = \max^m = pE$ at $90°$

- $T = 2\pi\sqrt{\frac{I}{pE}}$ $\omega = \sqrt{\frac{pE}{I}}$

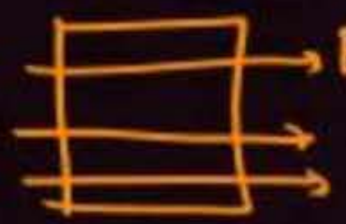
TBS capsule ⑧

Electric Flux

$$\phi = \vec{E} \cdot \vec{A}$$

$$\phi = EA\cos\theta.$$

$\theta \rightarrow$ angle b/w $\vec{E}$ & $\vec{A}$

- 

E → parallel to surface

⇓

$$\boxed{\phi = 0}$$

- Closed 3-D surface

⇓

uniform E

⇓

$$\boxed{\phi_{net} = 0}$$

$\phi_{in} = -ve$

$\phi_{out} = +ve$

Gauss law

$$\boxed{\phi = \oint \underline{\vec{E}} \cdot d\vec{s} = \frac{q_{encl}}{\epsilon_0}}$$

ϕ → due to inside charges.

$\vec{E}$ → due to all charges.

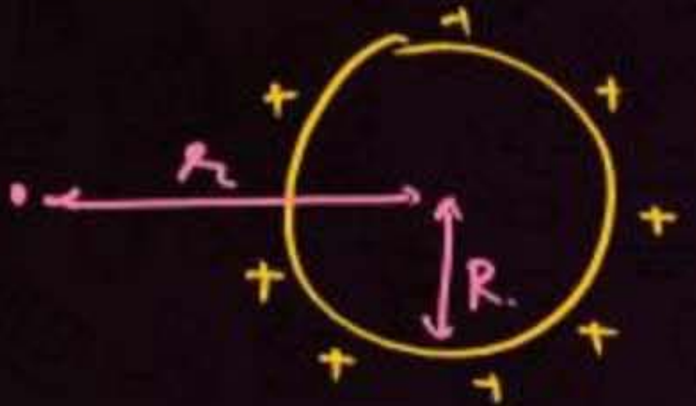
→ TBS Chart

• Object	Gaussian surface
① Pt. charge	Spherical
② Sphere	Spherical
③ Line charge (Rod)	Cylindrical
④ Sheet	Cylindrical or cuboid

① Hollow Sphere

&

Solid conducting

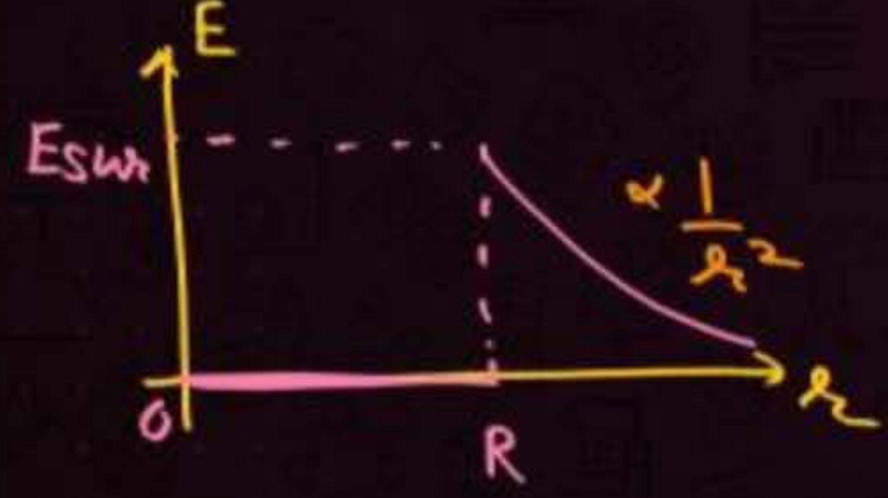


Like pt. charge

$$\boxed{E_{out} = \frac{kQ}{r^2}}$$

$$E_{sur} = \frac{kQ}{R^2} = \frac{\sigma}{\epsilon_0}$$

$$E_{in} = 0$$



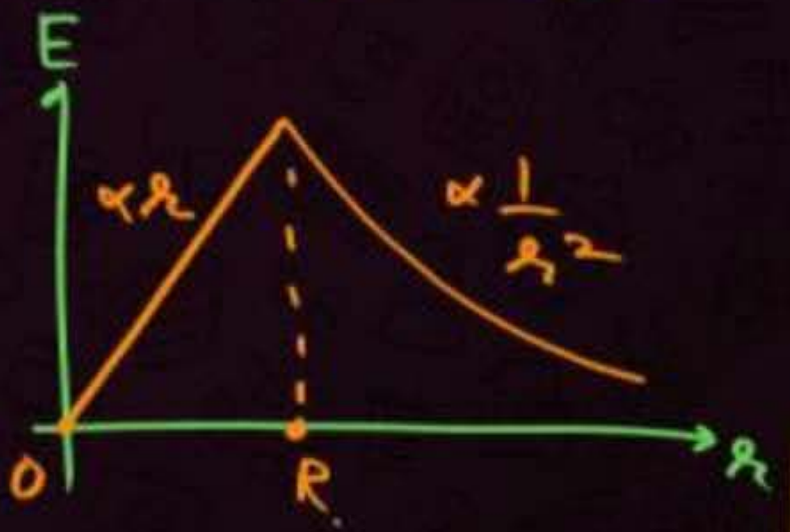
② Solid non-cond.

⇓

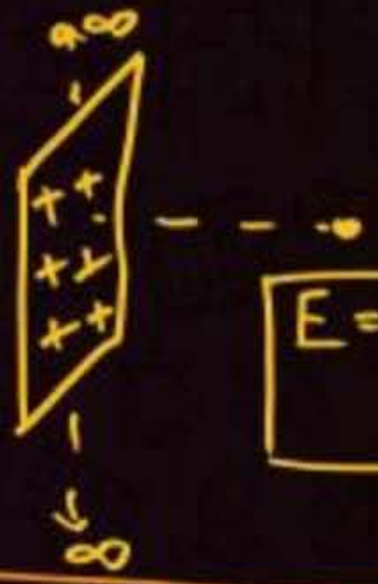
$$E_{out} = \frac{kQ}{r^2}$$

$$E_{sur} = \frac{kQ}{R^2} = \frac{\rho R}{3\epsilon_0}$$

$$E_{in} = \frac{kQr}{R^3} = \frac{\rho r}{3\epsilon_0}$$



③ Sheet (Non-cond.)



$$\boxed{E = \frac{\sigma}{2\epsilon_0}}$$

Cube ⇒ a) Body center

Cube → $\frac{q}{\epsilon_0}$ Face → $\frac{q}{6\epsilon_0}$

b) Face center → $\frac{q}{2\epsilon_0}$ (cube)

c) Edge center → $\frac{q}{4\epsilon_0}$ (cube)

d) Corner → $\frac{q}{8\epsilon_0}$ (cube)

Homework

10 am Subah DPP Battle - Ground

PW App

FOR NOTES & DPP CHECK DESCRIPTION

शुक्रिया !
ज़िंदा रहे तो फिर मिलेंगे