
VIJETA
2026 CLASS 12TH PHYSICS
ELECTRIC
CHARGES & FIELD
By- Akshay Tyagi Sir

Topics to be Covered

- Electric charges
- Coulomb's law in general form
- Electric field and Electric dipole
- Gauss's theorem


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REPEAT AND REVISE
AGAIN & AGAIN

Electric Chrages & Field

1. Electric Chrages
- Types - (+/-)
- Properties
  - Quantization
  - Conservation
  - Additivity
- Methods
  - Friction
  - Conduction
  - Induction

2. Coulomb's Law
- Scalar : $\vec{F} = \frac{|kq_1q_2|}{r^2}$
- Vector : $\vec{F}_{12} = \frac{k|q_1q_2|}{r^2}\hat{r}_{21}$
- Superposition (Vector sum)
- Dielectric : $F_m = \frac{F_0}{K}$

3. Electric Field (E)
- Defination : $E = \frac{F}{q_0}$
- Point Charge $E = \frac{kQ}{r^2}$
- Field lines (start +, end -, No cross tangent = E, Closer = Stronger)

4. Electric Dipole
- Defination - +q, -q at 2a)
- Moment - p=2aq, - to +
- Field
  - Axial $E_a = \frac{2kp}{r^3}$
  - Equatorial $E_e = \frac{kp}{r^3}$
- Torque - $\tau = pE\sin\theta$

5. Continuous charge
- Linear - $\lambda = \frac{dq}{dl}$
- Surface - $\sigma = \frac{dq}{dA}$
- Volume - $\rho = \frac{dq}{dV}$

6. Gauss's Law
- Flux - $\phi = \oint \vec{E} \cdot d\vec{A}$
- Law - $\phi = \frac{q_{enclosed}}{\varepsilon_0}$
- Application - inf Wire, Sheet, Shell)

Electric Charges

The study of electric charges at rest is called **Electrostatics.**

Positive Charge

Positive charge is produced by the removal of electrons from a neutral body. That is, positive charge means deficiency of electrons.

Negative Charge

Negative charge is produced by giving electrons to a neutral body. That is, negative charge means excess of electrons on a neutral body.

SI unit of charge is coulomb (C).

- **It is a fundamental property of matter due to which it experiences electric force.**

$\boxed{\text{proton} \rightarrow +\text{ive}}$

$\boxed{\text{electron} \rightarrow \ominus}$

Charge (Q) $\longrightarrow$ coulomb

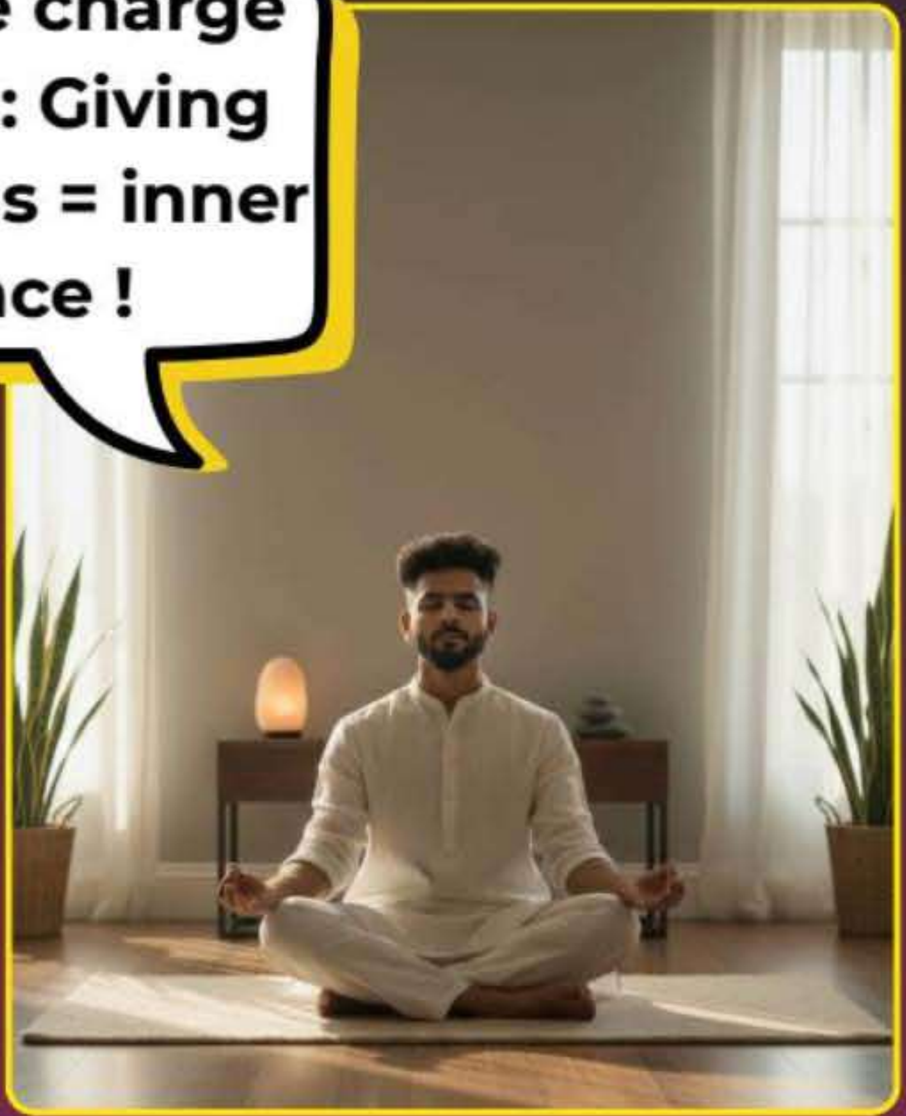
electron

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

proton

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

Electric Charges



Properties of Charges

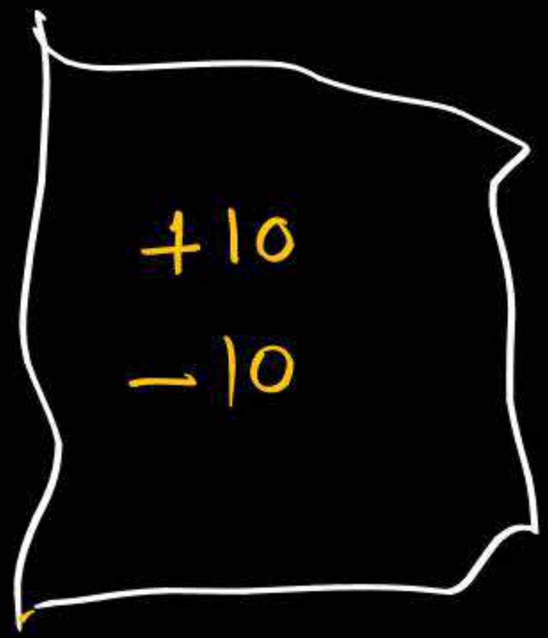
1. **Additive Property** : Total charge on an isolated system is equal to the algebraic sum of charges on individual bodies of the system. This is called additive property of charges. That is, if a system contains three charges, q_1, q_2, $-q_3$, then total charge on system,

$$Q = q_1 + q_2 - q_3$$

2. **Conservation of Charge** : The charge of an isolated system remains constant. This means that charge can neither be created nor destroyed, but it may simply be transferred from one body to another.

$+20$
-20 (Neutral)

$q_{net} = 0$



Neutral

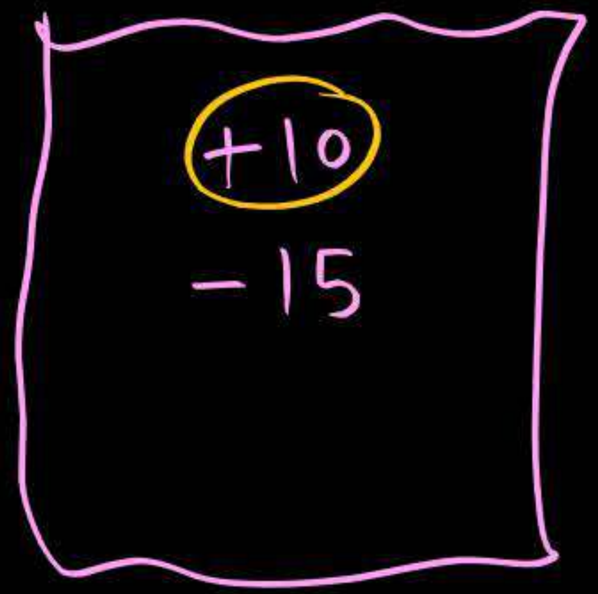
$q_{net} = 0$

$+30$ Before
-30 rubbing

After rubbing

$+20$
-15

$q_{net} = +5$



$q_{net} = -5$

$+30$ After
-30 rubbing

Properties of Charges

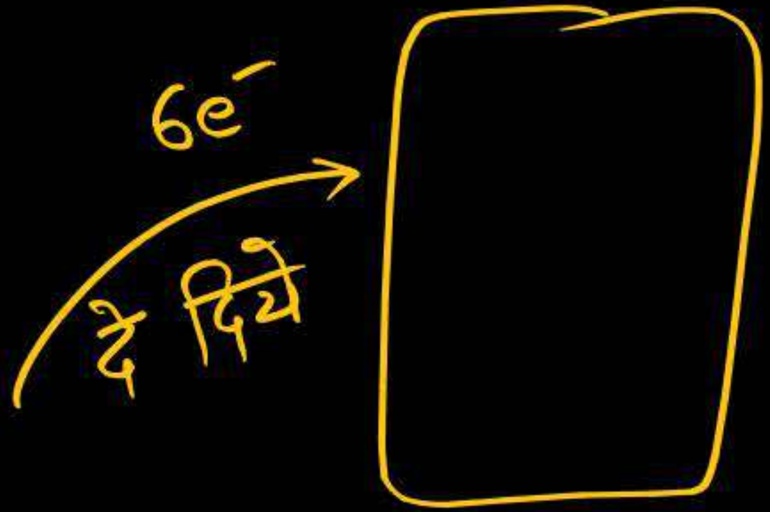
$e = 1.6 \times 10^{-19}\, C$

3. **Quantisation of Charge :** The total charge on a body is the integral multiple of fundamental charge 'e'

$q = \boxed{\pm}\, ne$ where n is an integer (n = 1,2,3, ...)

4. Like charges repel while unlike charges attract each other.

5. Charge is invariant.



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

$$6e^- = 6(-1.6 \times 10^{-19})$$

$$= -9.6 \times 10^{-19}\ C$$

$$\boxed{Q = \pm Ne}$$

An object has charge of 1 C and gains 5.0×10^{18} electrons. The net charge on the object becomes

PYQ - 2022

A -0.80 C

B +0.80 C

C +1.80 C

D +0.20 C

$q = +1C$

+1C

gains

$N = 5 \times 10^{18}$

$\Downarrow$

$Q = -Ne$

$= -5 \times 10^{18} \times 1.6 \times 10^{-19}$

$= -8.0 \times 10^{-1}$

$= -0.80\,C$

$Q_{net} = +1 - 0.80$

$= +0.20\,C$

A → last tak

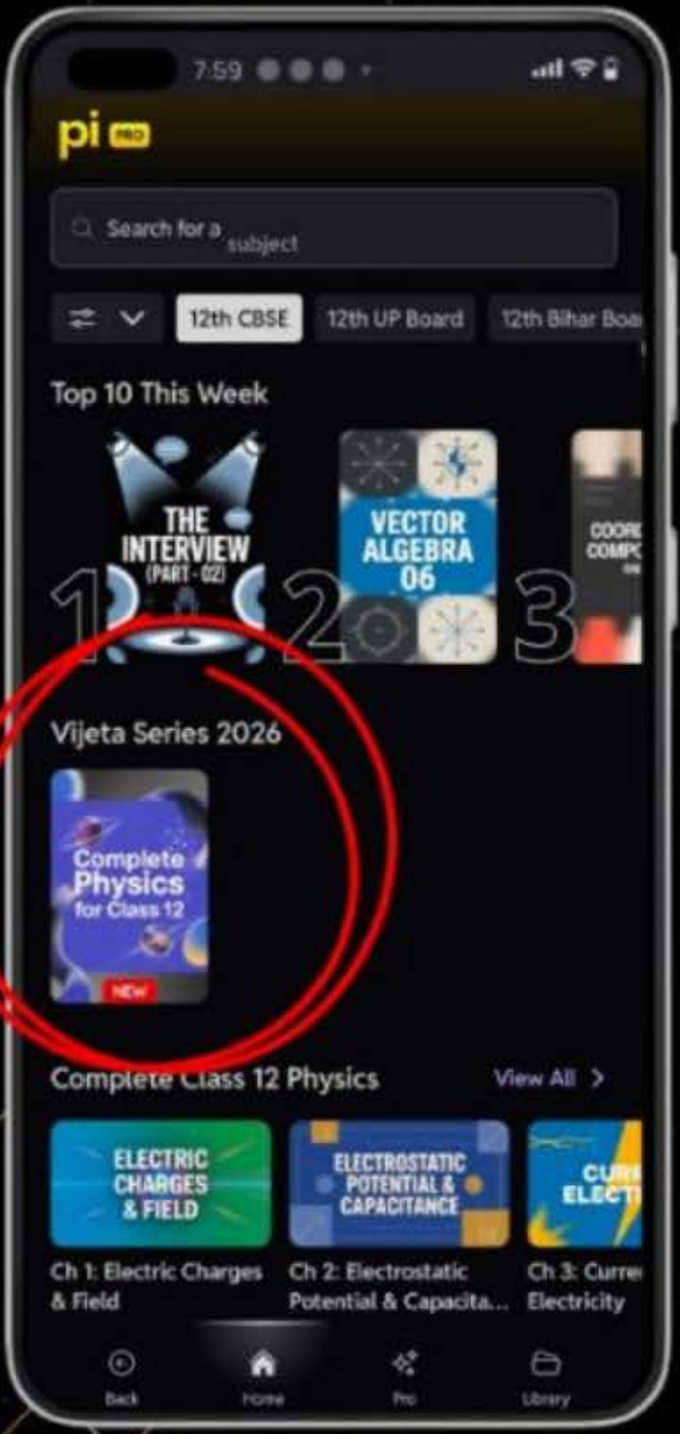
B → Give up

C → Beech में

D → गायो - है?

Vijeta 2026

YT Series
Free



1. All recorded classes of **Vijeta Series** will be available for revision in the pi section of the PW app.

2. **Free Notes** for every class will be available on the PW App (Pi).

3. **Weekly Schedule** will be shared on our NCERT Wallah YT channel Community section

Link in Description

When a piece of polythene is rubbed with wool, a charge of -2×10^{-7} C is developed on polythene. What is the amount of mass, which is transferred to polythene.

(JEE Mains PYQ)

A) 1.1×10^{-18} kg

B) 2.2×10^{12} kg

C) 3.3×10^{-14} kg

D) None

$$Q = -Ne$$

$$-2 \times 10^{-7} = -N \times 1.6 \times 10^{-19}$$

$$\frac{2 \times 10^{-7}}{1.6 \times 10^{-19}} = N$$

$$\frac{20}{1.6} \times 10^{-7+19} = N$$

$$\boxed{N = 1.25 \times 10^{12}}$$

mass of $e^- = 9.1 \times 10^{-31}$ kg

Total mass $= N \times$ mass of $1e^-$

$= 1.25 \times 10^{12} \times 9.1 \times 10^{-31}$

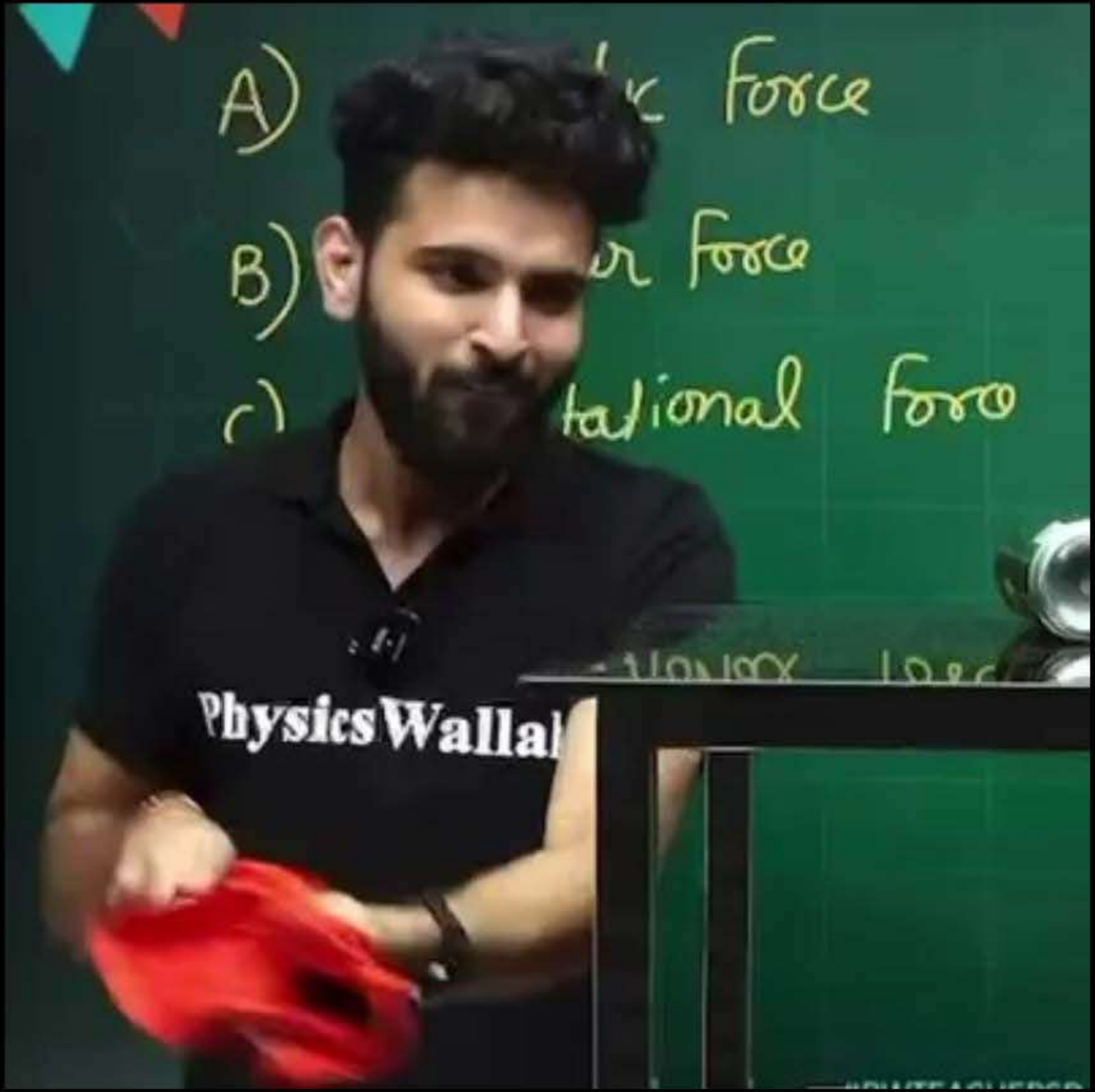
$= 1.1 \times 10^{-18}$ kg

Types of Material

- Conductor
- Insulator
- Semiconductor

Method of Charging

- Friction
- Conduction
- Induction


A) Force
B) Force
PhysicsWalla

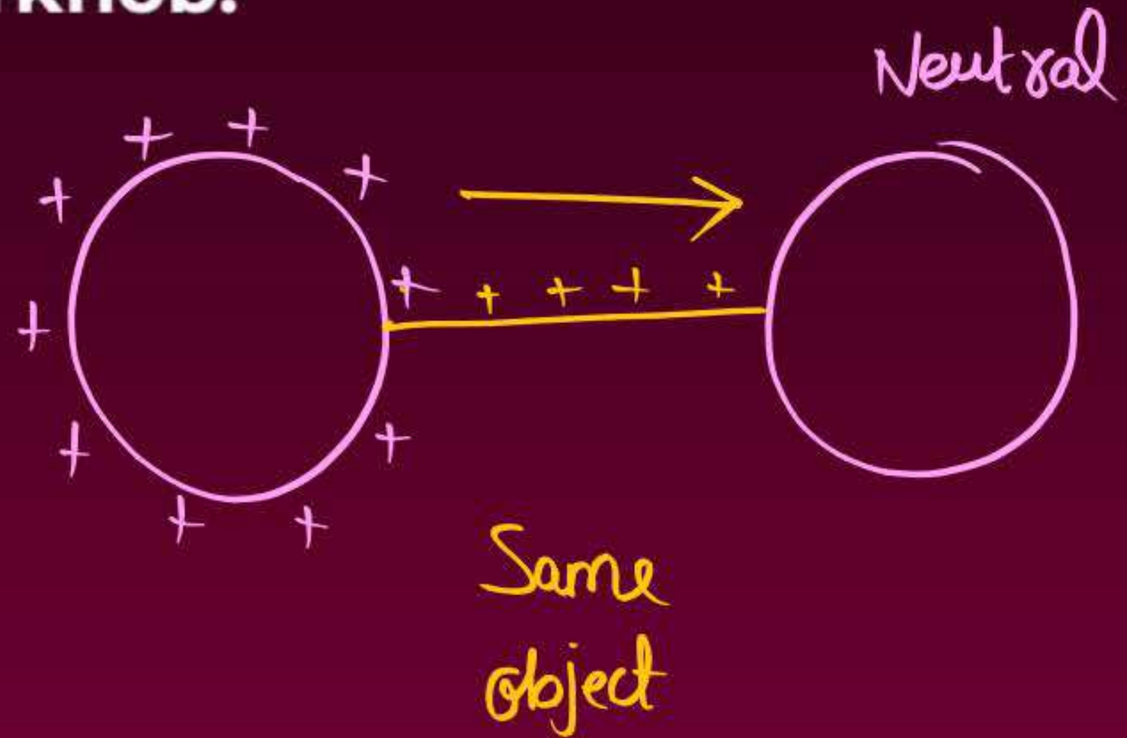
Charging by Friction

When two objects are rubbed together, the molecules are close enough together that the electrons from one substance can move onto the other substance.

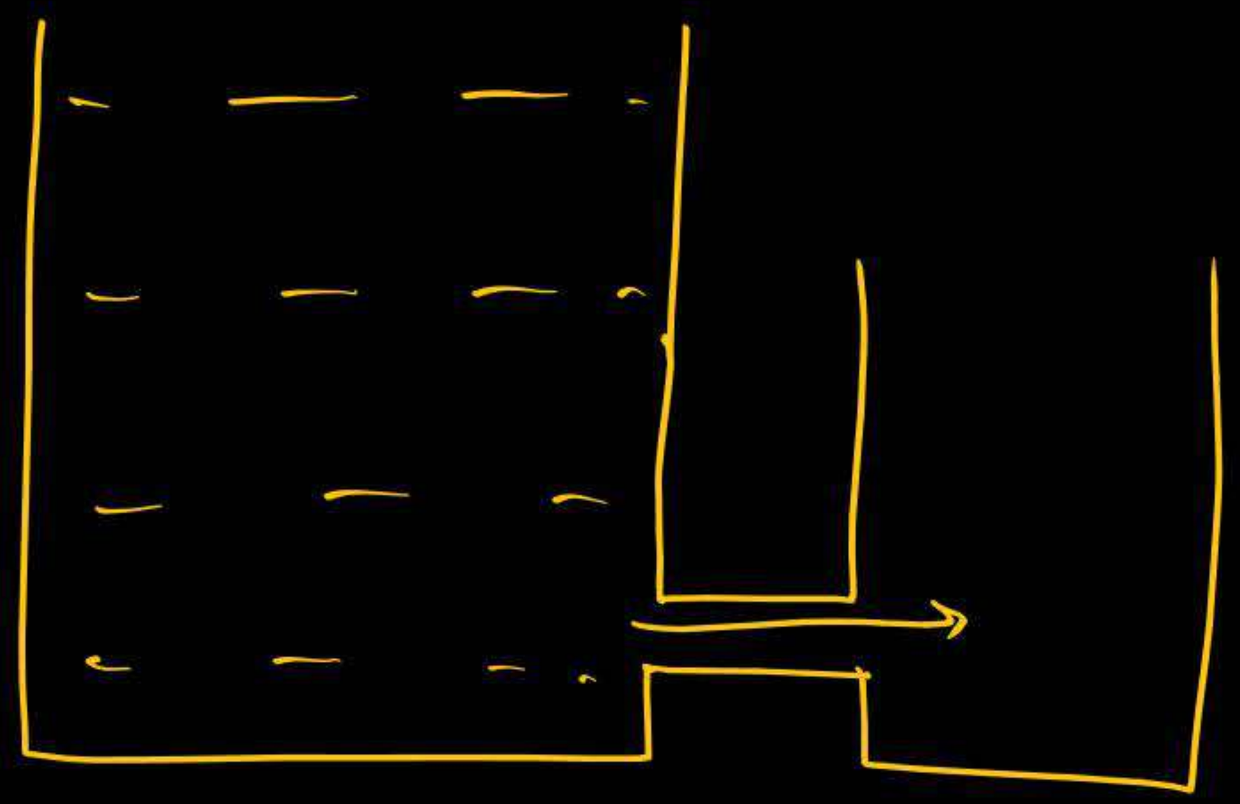
Charging by Conduction (only in conductors)

Charging by conduction, also known as charging by contact, involves transferring charge from a charged object to a neutral object by direction physical contact. This process results in both objects acquiring the same type of charge, although they may have different magnitudes of charge.

Example : Walking on carpet, then touching the doorknob.

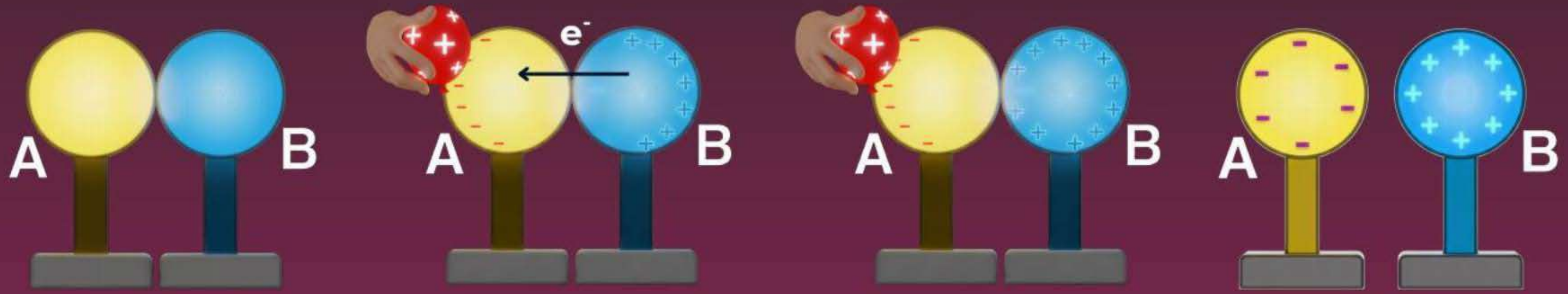


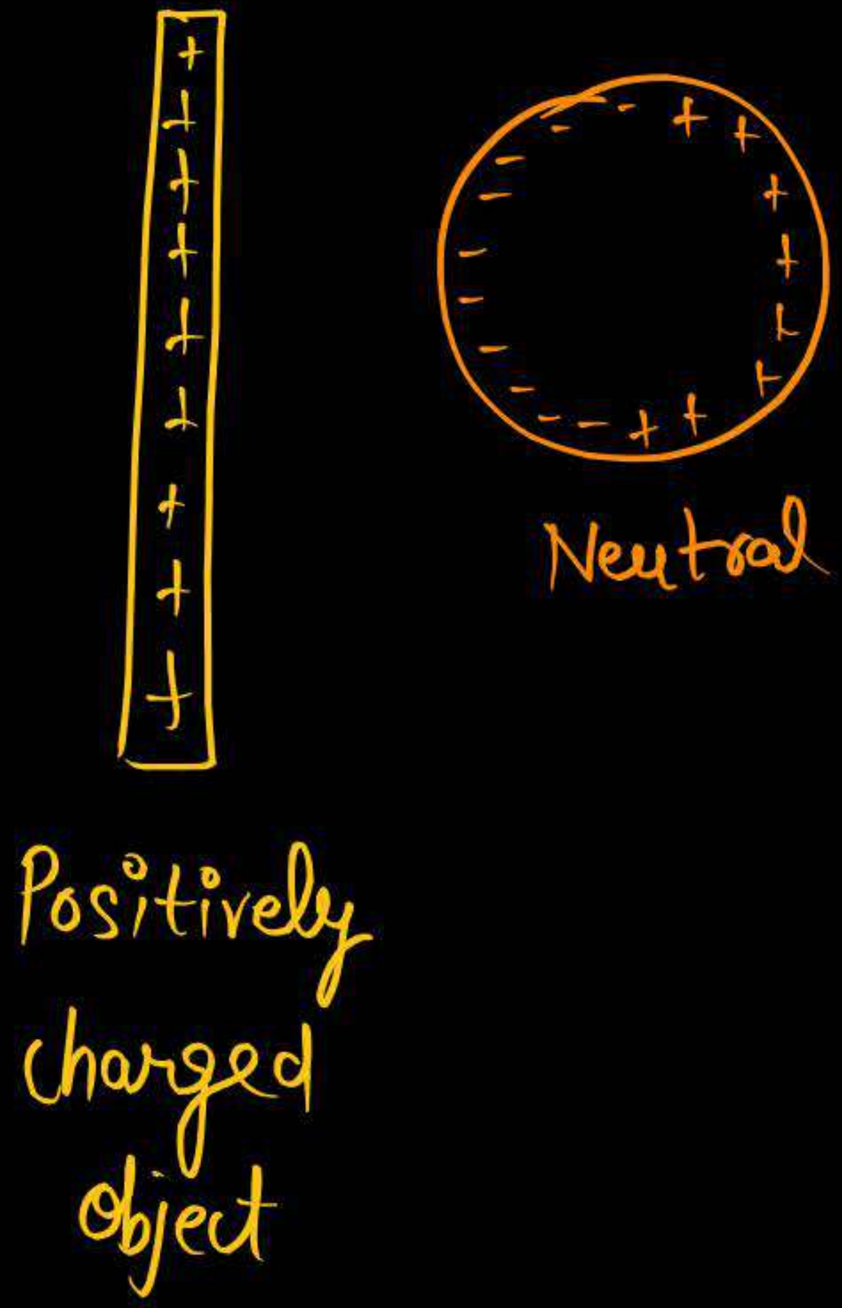
Charge will flow until both gets equally charged.

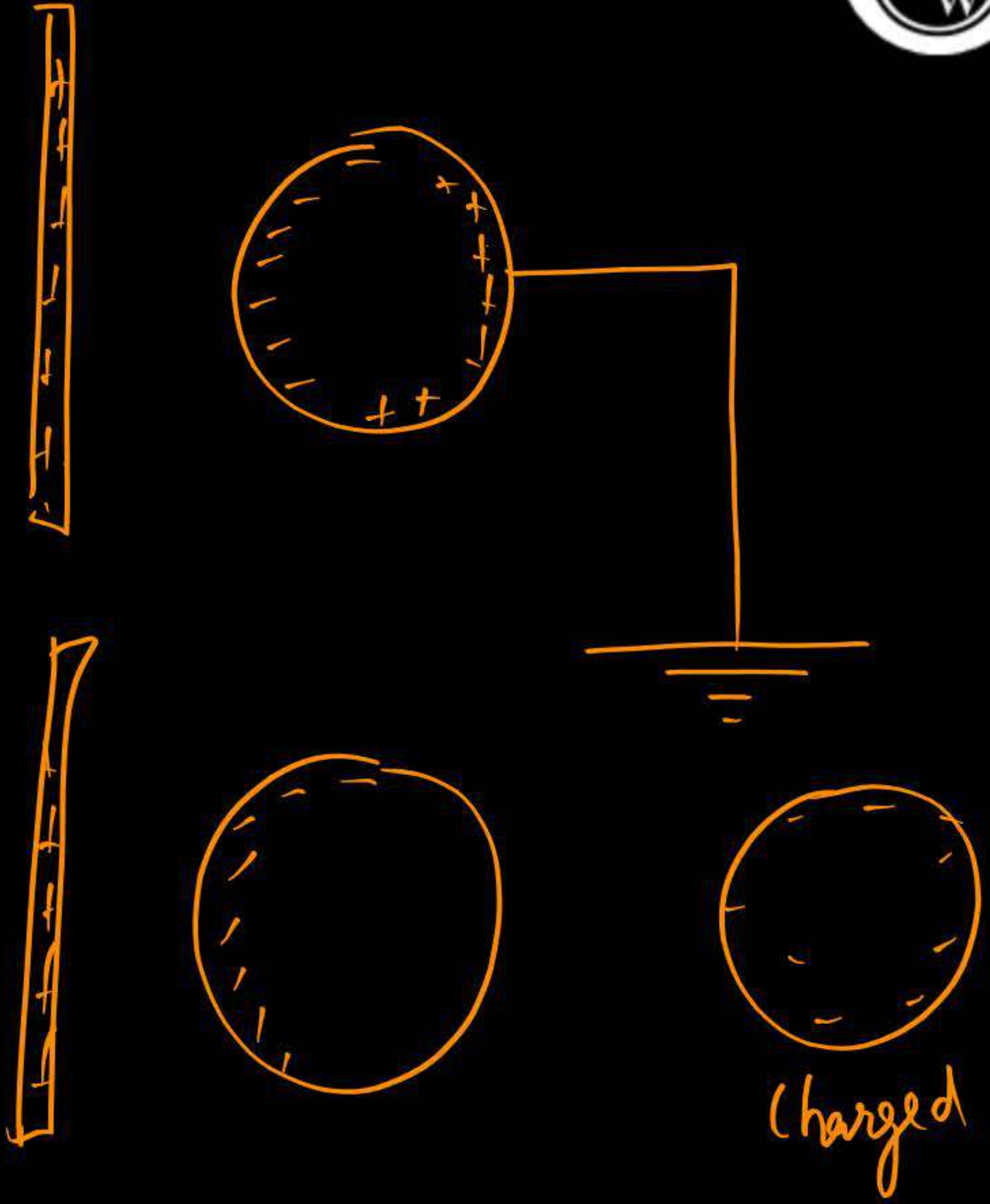


Charging by Induction

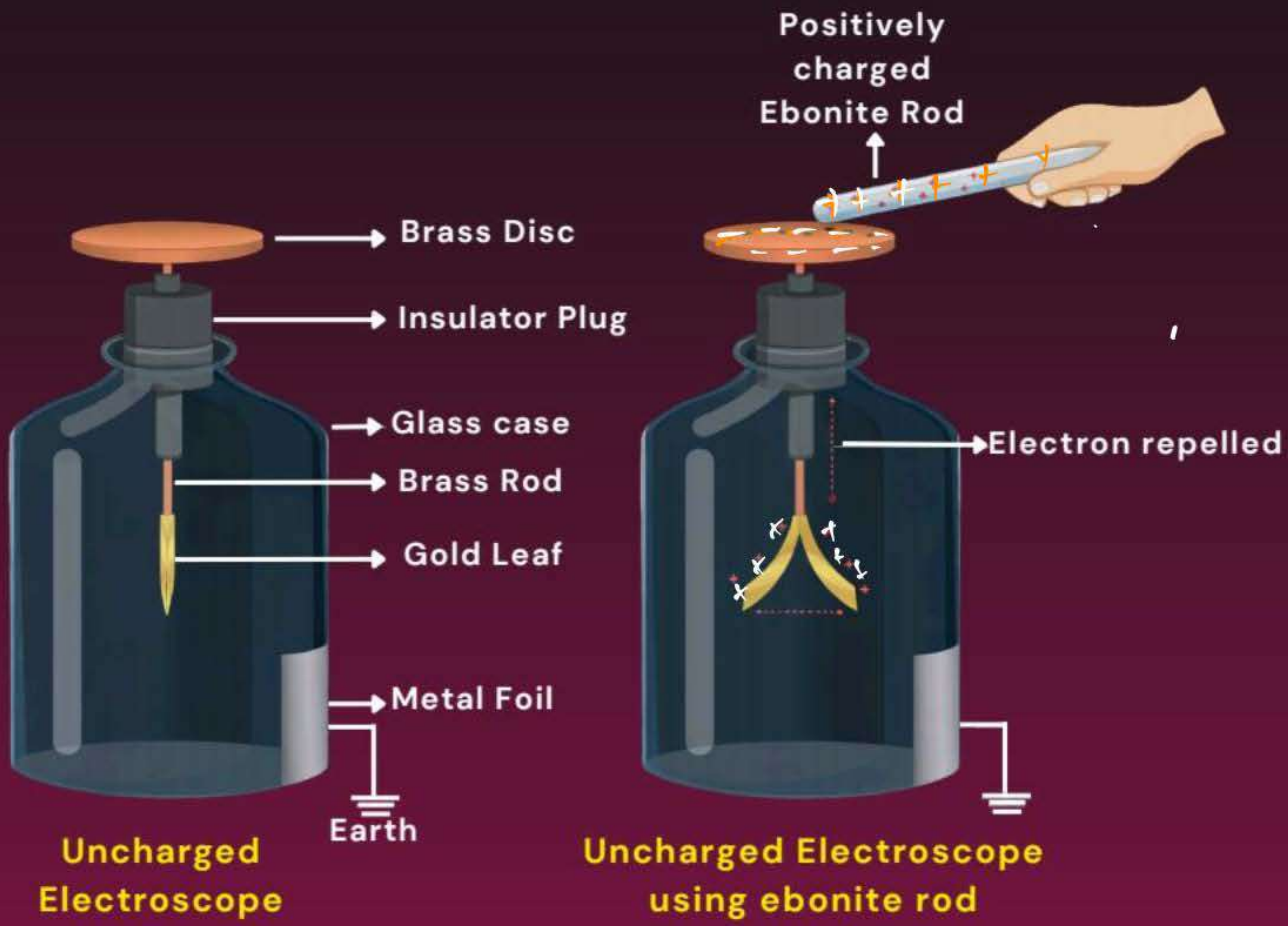
Charging by induction is a method of charging a neutral object without physically touching it with a charged object. It involves bringing a charged object near a neutral conductor, which causes a redistribution of charges within the conductor, leading to the neutral object becoming charged with an opposite polarity to the charged object.




Neutral
Positively charged object


Charged

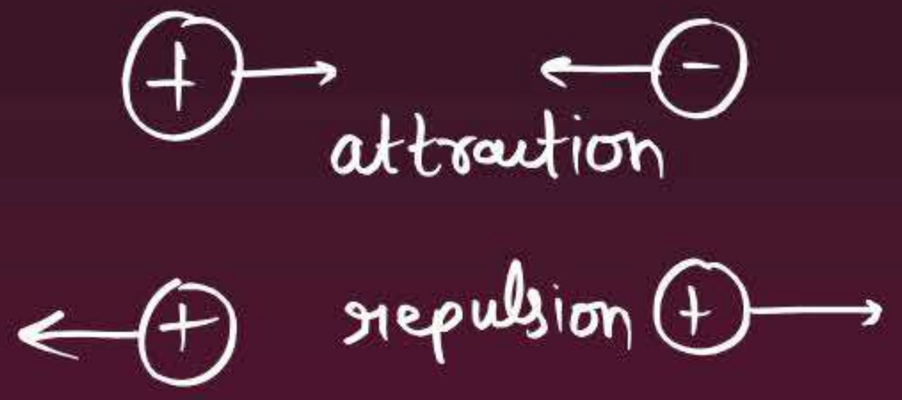
Gold Leaf Electroscope



Coulomb's Law in General Form

It states that the force of attraction or repulsion between two point charges is directly proportional to the product of magnitude of charges and inversely proportional to the square of distance between them. The direction of this force is along the line joining the two charges.

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



For free space k = 1. $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$

$F \propto q_1 q_2$

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

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

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

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

$\varepsilon_r = k$

dielectric constant

vaccuum

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

ε_0 = permittivity of space

$= 8.85 \times 10^{-12}\ C^2/Nm^2$

$K = 9 \times 10^{9}\ Nm^2/C^2$

Medium

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

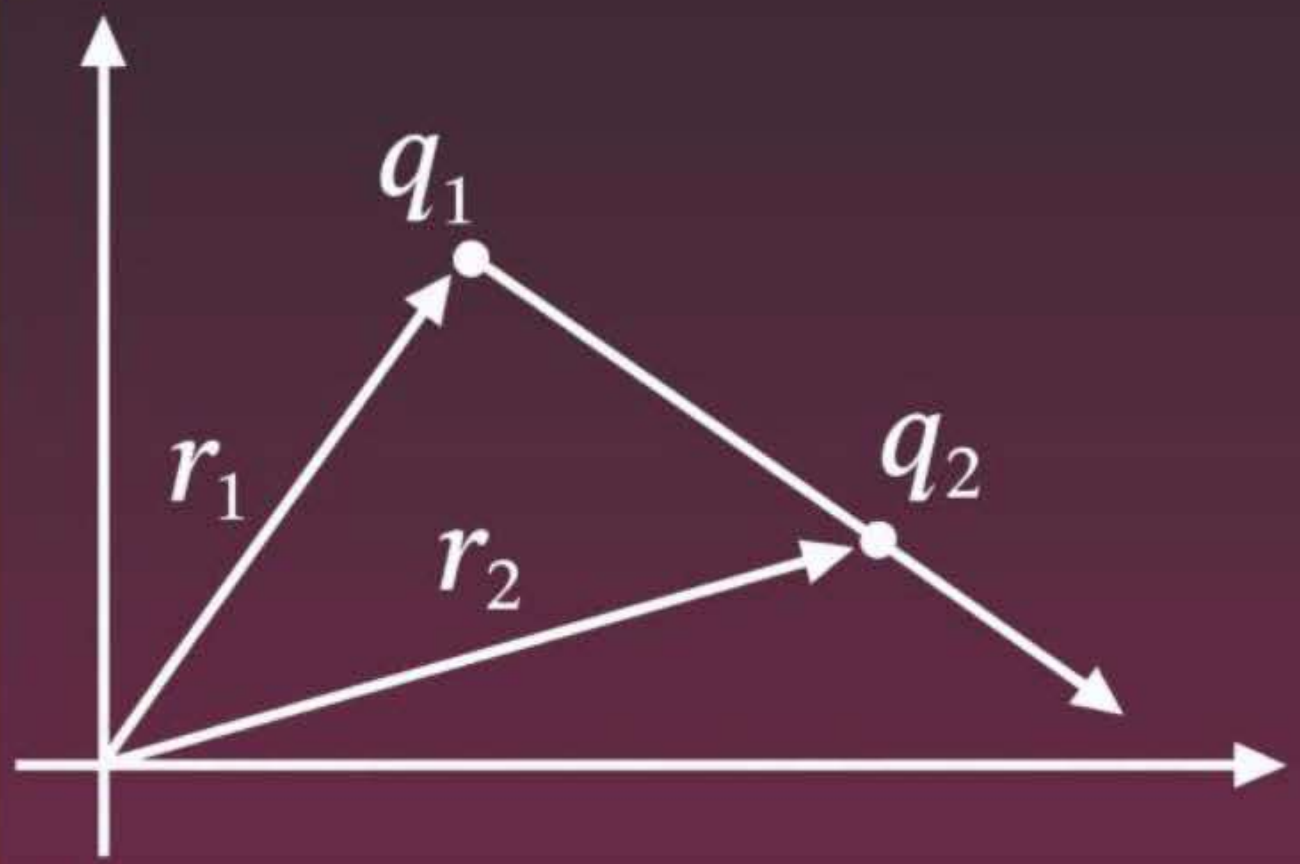
$\varepsilon_m = \varepsilon_0 \varepsilon_r$

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

$\varepsilon_m = \varepsilon_0 k$

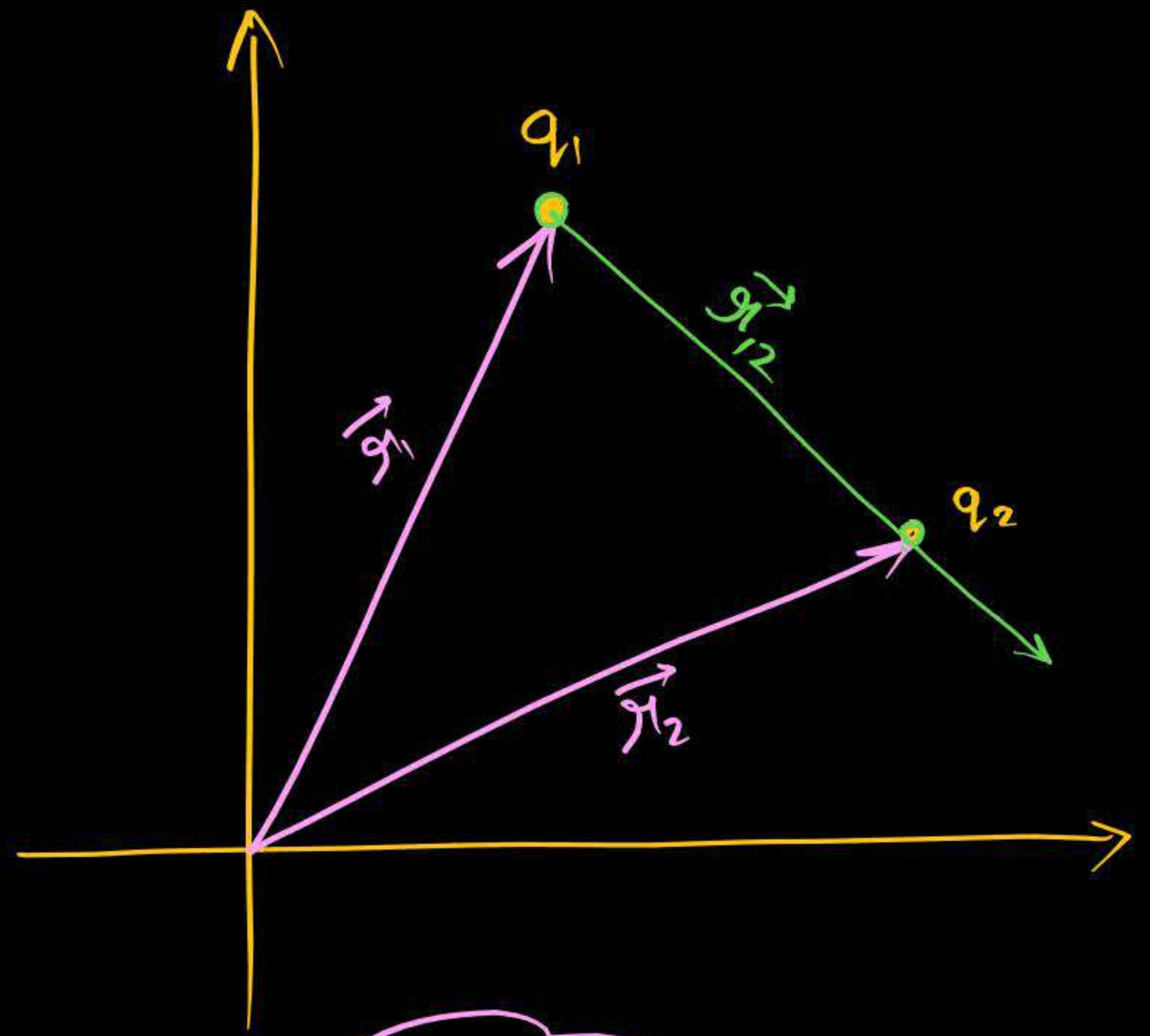
$$\boxed{F_m = \frac{1}{4\pi\varepsilon_0 k} \frac{q_1 q_2}{r^2}}$$

Coulomb's Law in Vector Form



$$\vec{F}_{21} = k\,\frac{q_1 q_2\,\hat{r}_{12}}{|\vec{r}_{12}|^2}$$

$$\vec{F}_{21} = k\,\frac{q_1 q_2\,\vec{r}}{|\vec{r}_{12}|^2}$$



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

Force on q_2 by q_1

$$\boxed{\vec{F}_{21} = \frac{K q_1 q_2}{r^2}\,\hat{r}_{12}}\ *$$

$$\Downarrow$$

$$\vec{F}_{21} = \frac{K q_1 q_2}{r^2}\,\frac{\vec{r}_{12}}{r}$$

$$\boxed{\vec{F}_{21} = \frac{K q_1 q_2}{r^3}\,\vec{r}_{12}}\ *$$

Two identical point charges, q each, are kept 2 m apart in the air. A third point charge Q of unknown magnitude and sign is placed on the line joining the charges such that the system remains in equilibrium. Find the position and nature of Q.

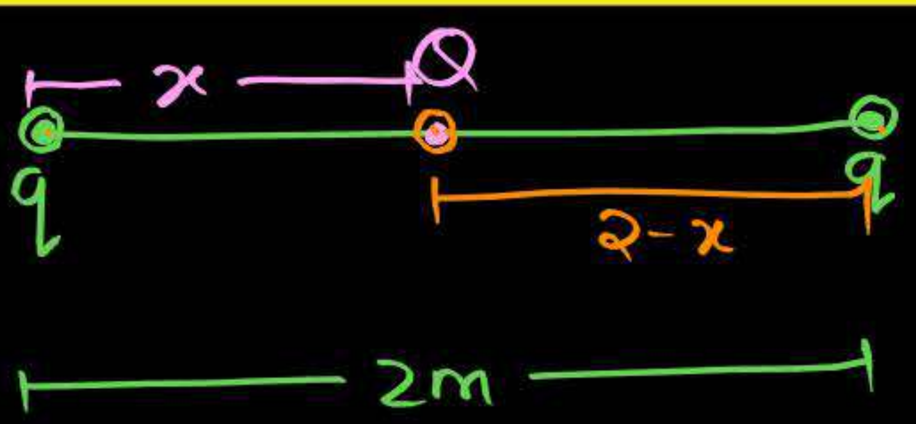
(Board 2019,23)

A) $q/8$

B) $-q/2$

C) $-q/4$

D) None



$F_1 = F_2$

$$\frac{\cancel{KqQ}}{x^2} = \frac{\cancel{KqQ}}{(2-x)^2}$$

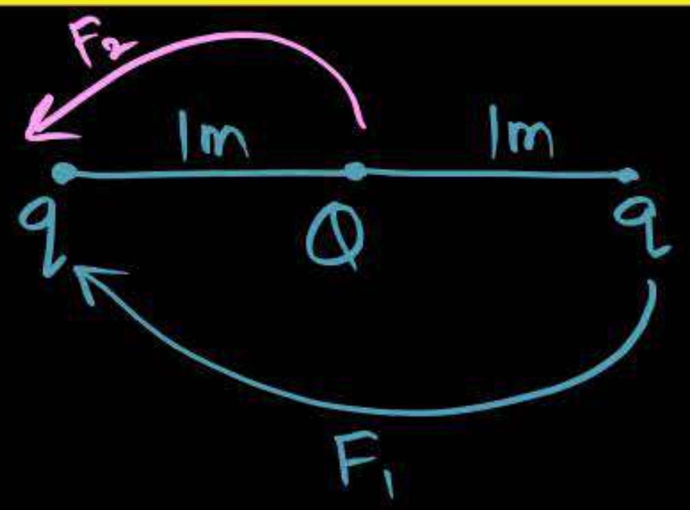
$$(2-x)^2 = x^2$$

$$2-x = x$$

$$2 = x + x$$

$$2 = 2x$$

$$\boxed{x = 1\,m}$$



$F_1 + F_2 = 0$

$$\frac{Kqq}{2^2} + \frac{KqQ}{1^2} = 0$$

$$\frac{\cancel{K}q^{\cancel{2}}}{4} = -\cancel{K}\cancel{q}Q$$

$$-\frac{q}{4} = Q$$

Two identical conducting spheres P and S with charge Q on each, repel each other with a force 16 N. A third identical uncharged conducting sphere R is successively brought in contact with the two spheres. The new force of repulsion between P and S is:

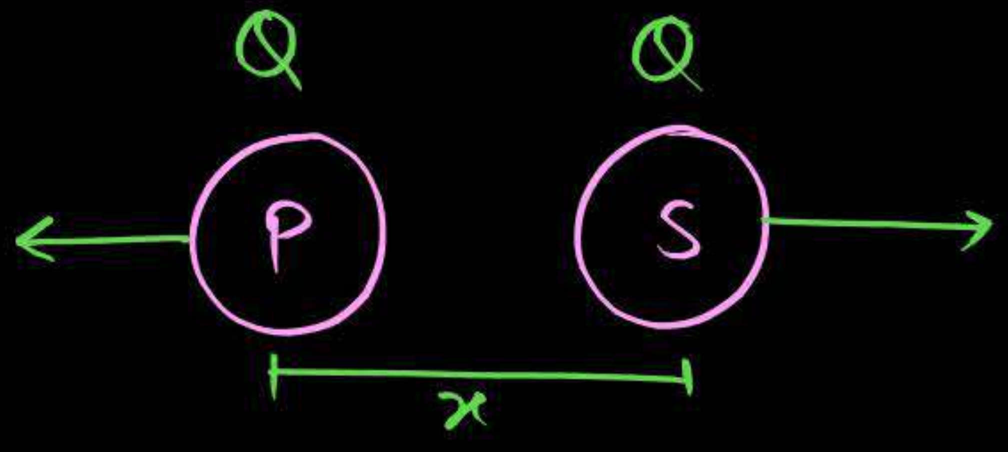
(JEE Mains 2024)

A 4 N

B 6 N

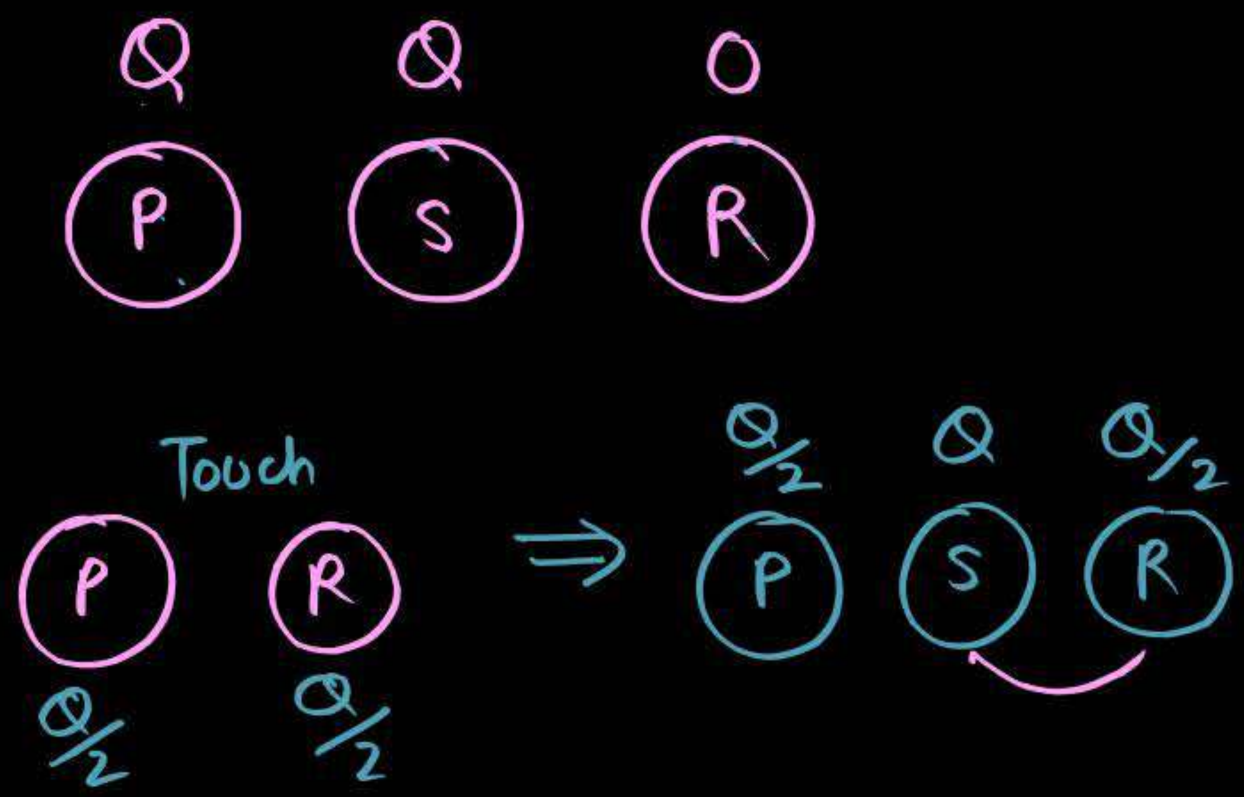
C 1 N

D 12 N



$$F = \frac{KQQ}{x^2} = 16$$

$$\frac{KQ^2}{x^2} = 16 \quad \text{—} \ (1)$$



P S R

$Q \quad Q \quad 0$

P R

$\Downarrow \quad \Downarrow$

$\frac{Q}{2} \quad \frac{Q}{2}$

$$\frac{Q+0}{2} = \frac{Q}{2}$$

P S R

$\frac{Q}{2} \quad Q \quad \frac{Q}{2}$

S $\frac{3Q}{4}$ R $\frac{3Q}{4}$

$$\frac{\frac{Q}{1}+\frac{Q}{2}}{2} = \frac{\frac{2Q+Q}{2}}{2}$$

$$= \frac{3Q}{4}$$

$$F' = \frac{K\left(\frac{Q}{2}\right)\left(\frac{3Q}{4}\right)}{x^2}$$

$$F' = \frac{KQQ}{x^2}\,\frac{3}{8}$$

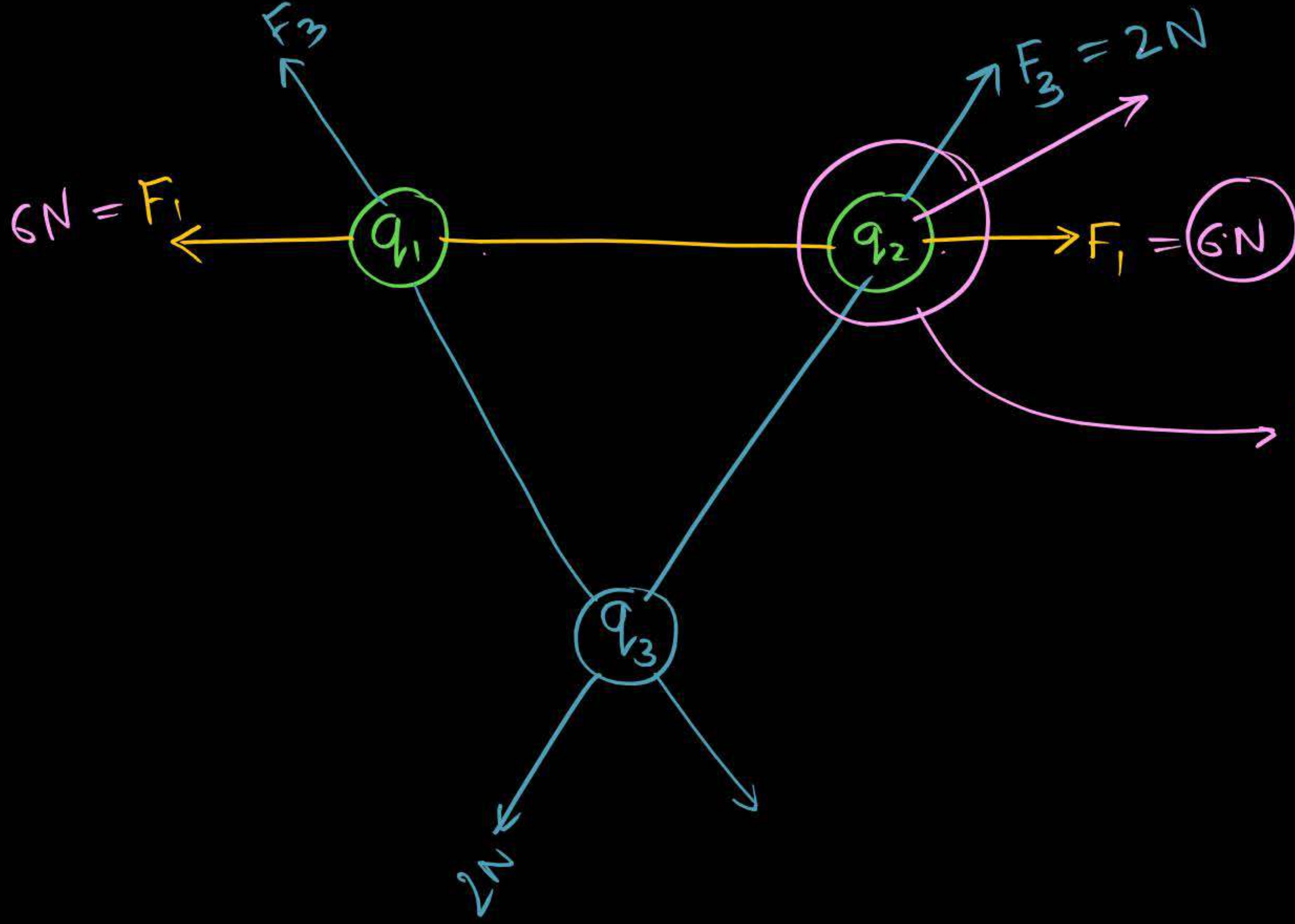
$$= \cancel{16}^{\,2} \times \frac{3}{\cancel{8}}$$

$$F' = 6N$$

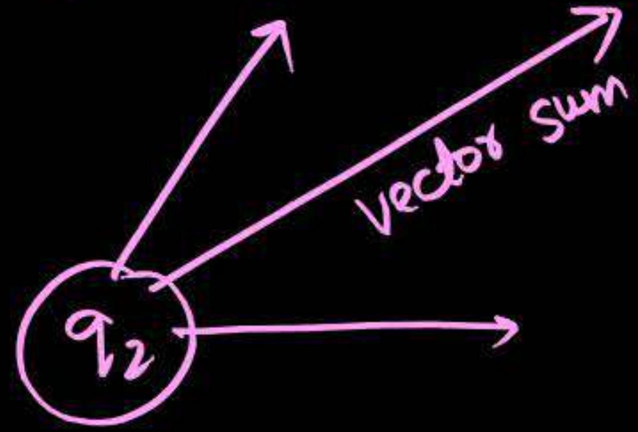
Principle of Superposition of Electric Charges

If the system contains a number of interacting charges, then the force on a given charge is equal to the vector sum of the forces exerted on it by all remaining charges.

$$\vec{F}_{net} = \boxed{\vec{F}_1 + \vec{F}_2 + \dots}$$



Net force on charge q_2



Electric Field and Electric field Intensity

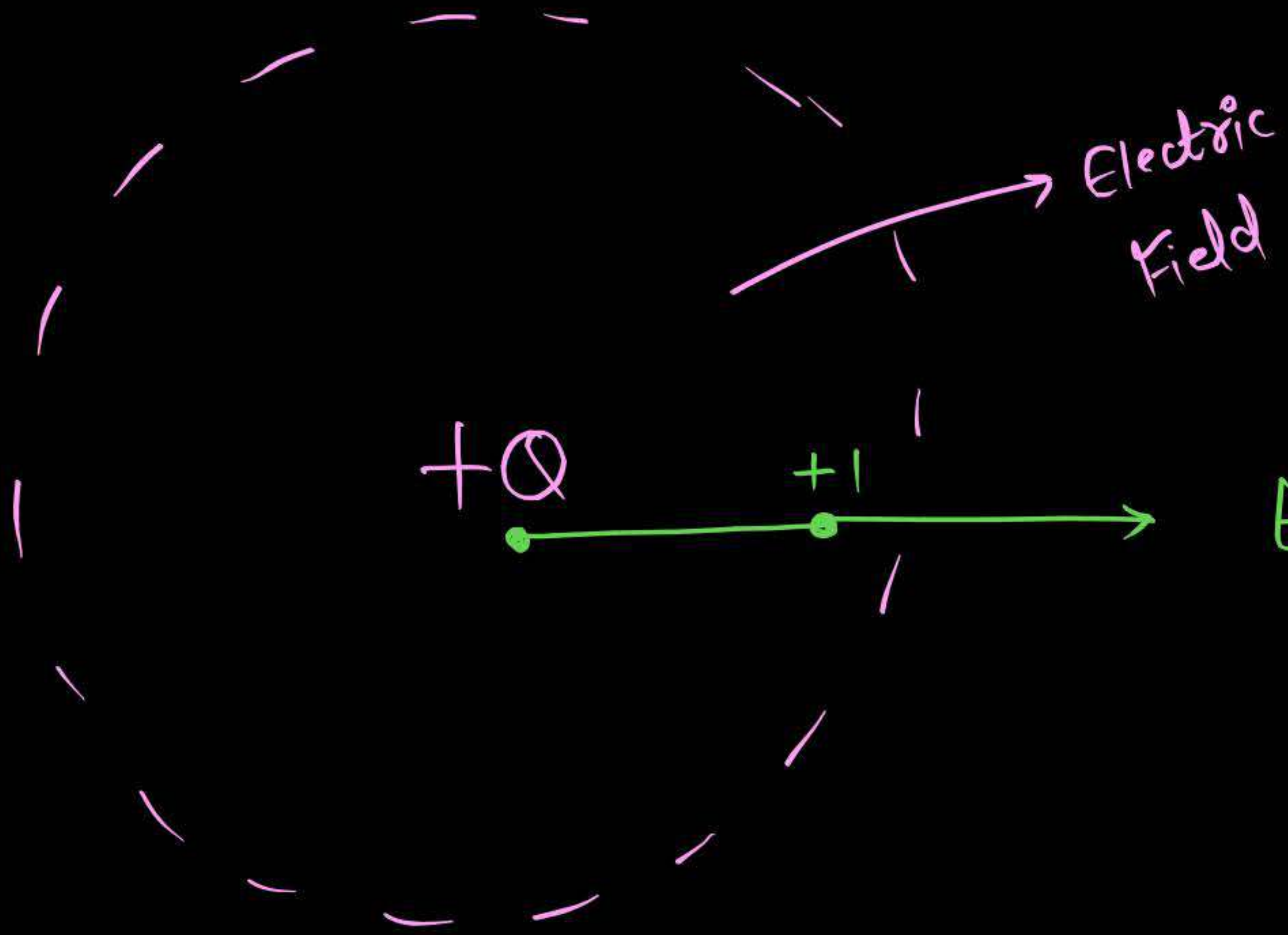
The region around an electric charge where another charge experiences a force.

The electric field strength at any point in an electric field is a vector quantity whose magnitude is equal to the force acting on a unit positive test charge and the direction is along the direction of force.

If F is the force acting on infinitesimal positive test charge q_0, then electric field strength,

$$\vec{E} = \frac{\vec{F}}{q_0} \Rightarrow \boxed{E = \frac{KQ}{x^2}} \Rightarrow N/C \text{ or volt/metre}$$

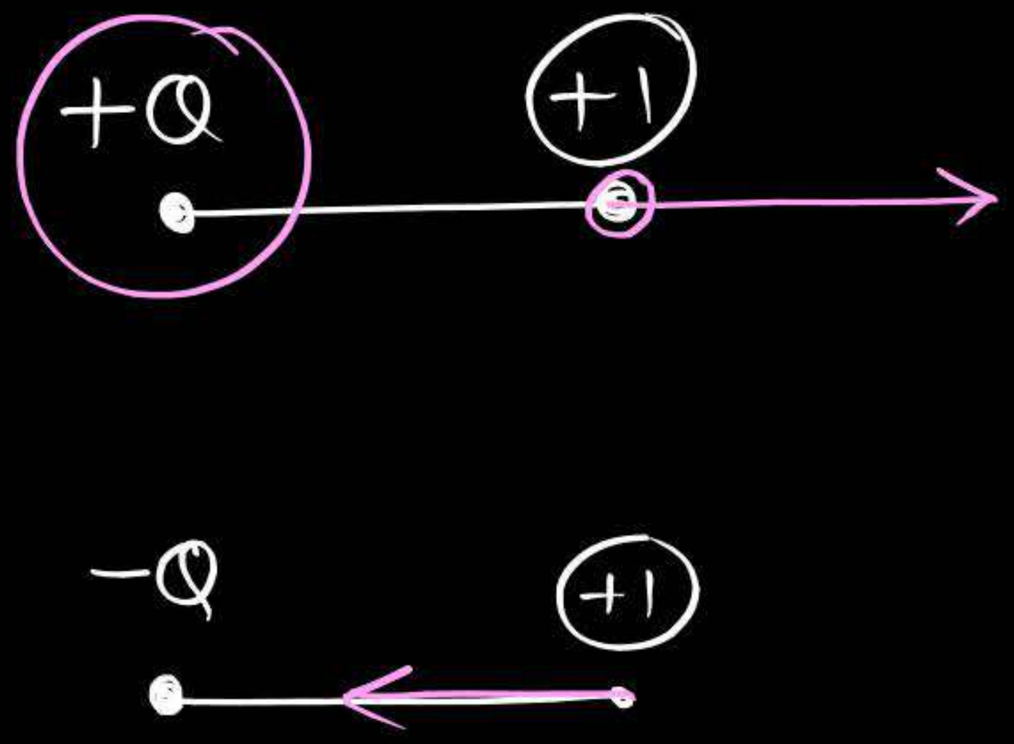
The unit of electric field strength is newton/coulomb or volt/metre.

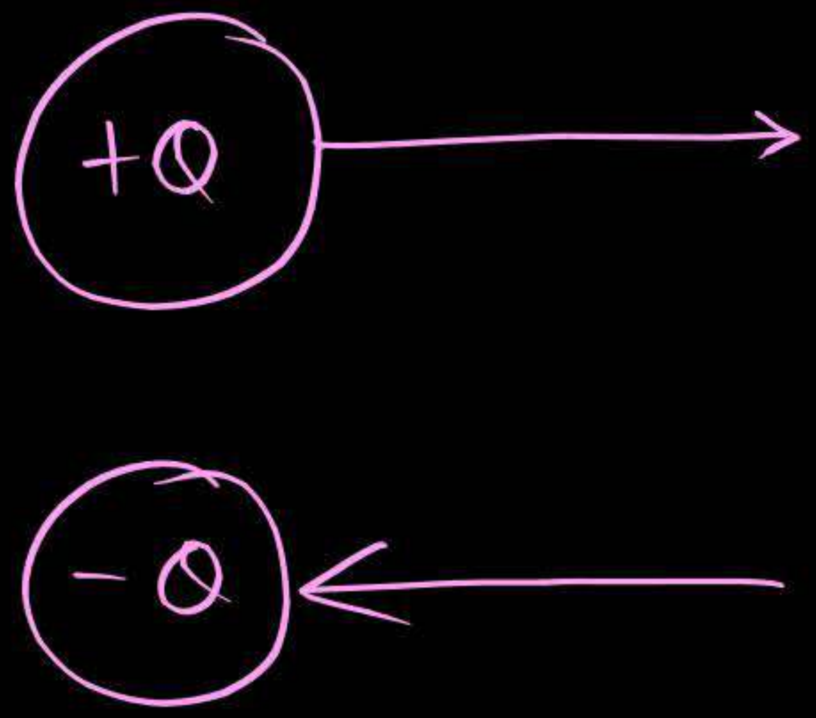


$$E = \frac{F}{q}$$

$$= \frac{kQ\cancel{q}}{x^2 \cancel{q}}$$

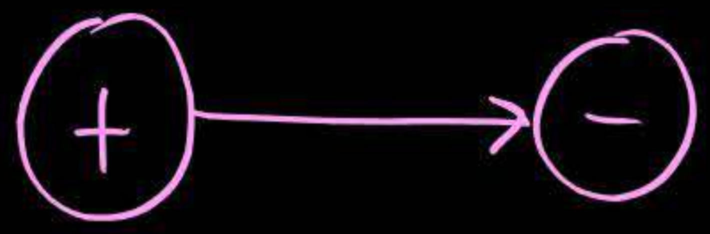
$$\boxed{E = \frac{kQ}{x^2}}$$





Direction of Electric Field

positive to negative

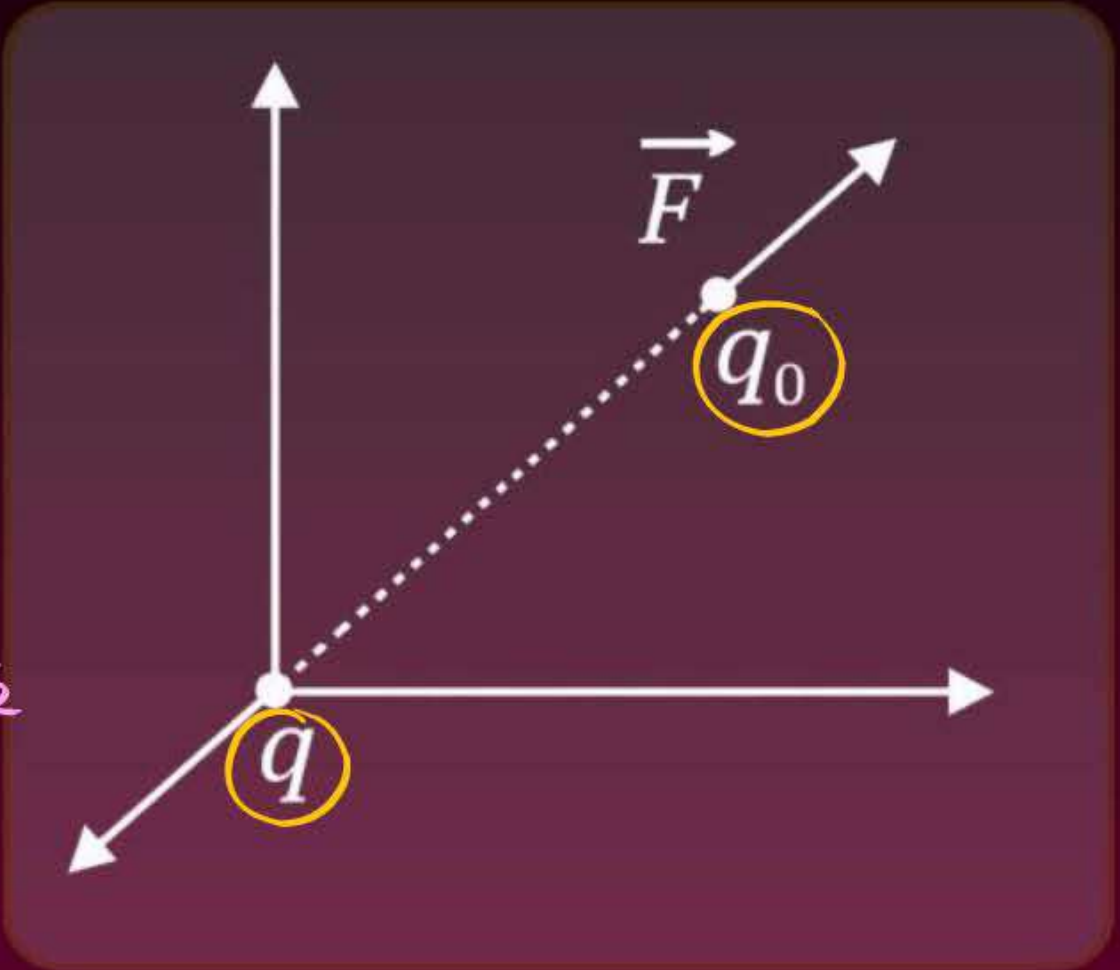


Electric Field

The electric field strength due to a point charge q at a distance r in magnitude form

$$|\boldsymbol{E}| = \frac{|\boldsymbol{F}|}{q_0} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

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



Three point charges, 1 pC each, are kept at the vertices of an equilateral triangle of side 10 cm. Find the net elctric field at the centroid of triangle.

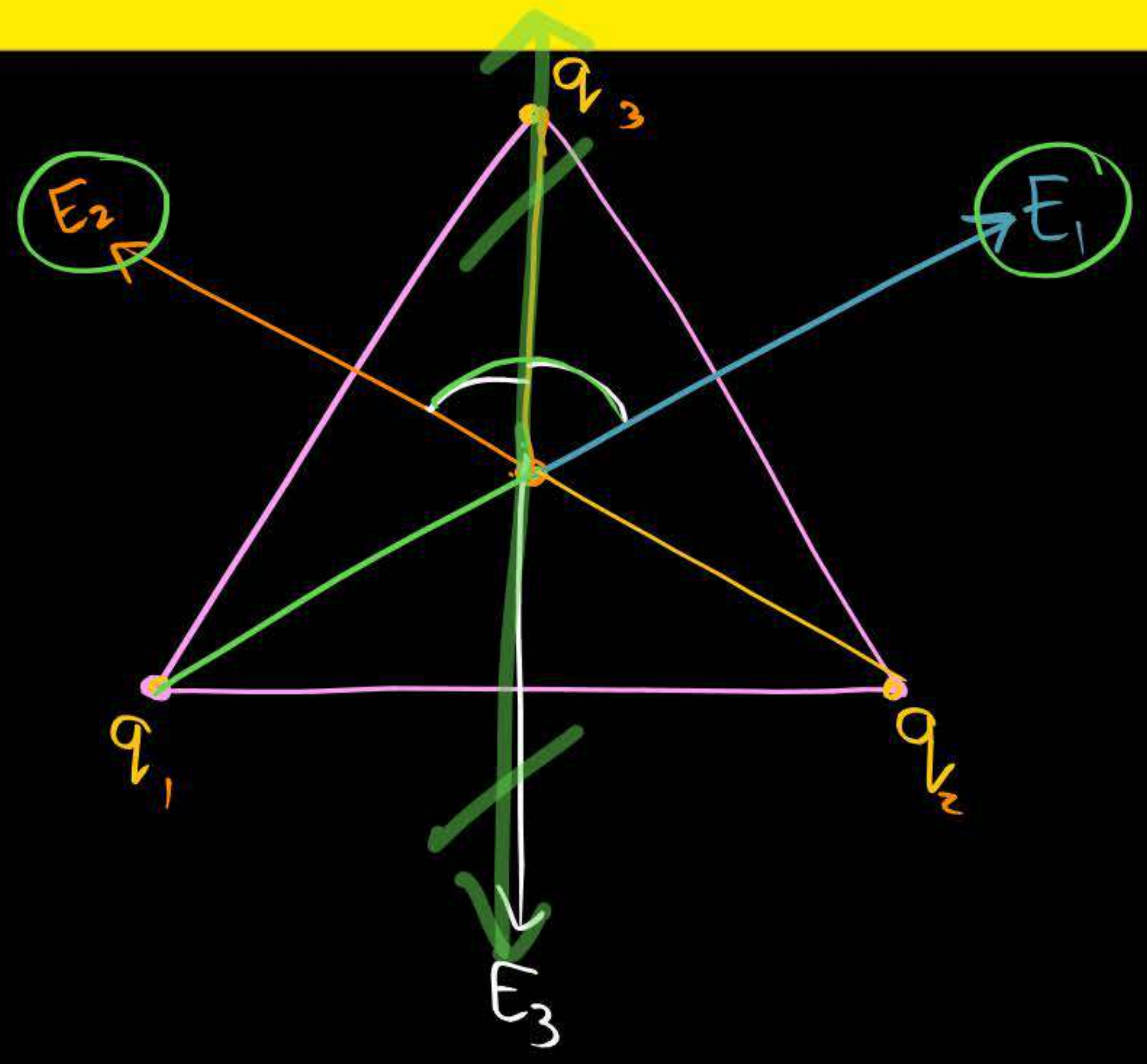
(2024)

A) 20

B) 0

C) 10

D)



$\cos 120° = -\frac{1}{2}$

For E_1 and E_2

$$E_{12} = \sqrt{E_1^2 + E_2^2 + 2E_1E_2\cos\theta}$$

$$E_{12} = \sqrt{E^2 + E^2 + 2EE\cos 120°}$$

$$E_{12} = \sqrt{2E^2 + \cancel{2}E^2 \times \left(-\frac{1}{\cancel{2}}\right)}$$

$$= \sqrt{2E^2 - E^2}$$

$$= \sqrt{E^2} = E$$

A point charge +q is placed at the origin. A second point charge +9q is placed at (d, 0, 0) in Cartesian coordinate system. The point in between them where the electric field vanishes is:

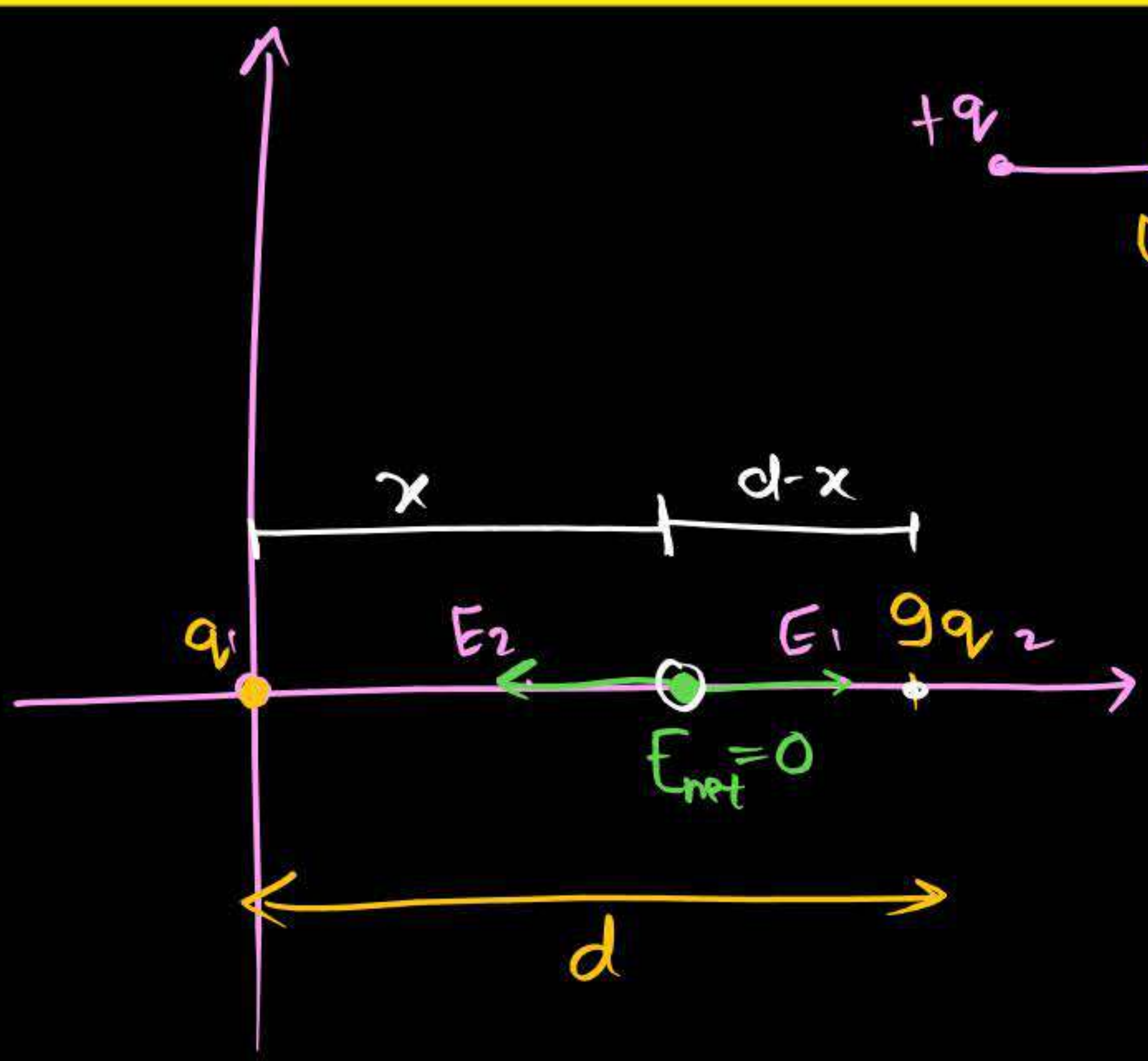
(JEE Mains 2025)

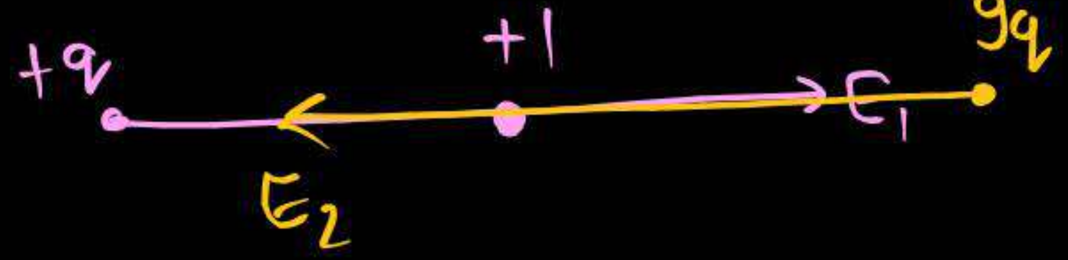
A (3d/4, 0, 0)

B (d/4, 0, 0)

C (4d/3, 0, 0)

D None





$$E_1 = E_2$$

$$\frac{\cancel{K}\cancel{q}}{x^2} = \frac{\cancel{K}(9\cancel{q})}{(d-x)^2}$$

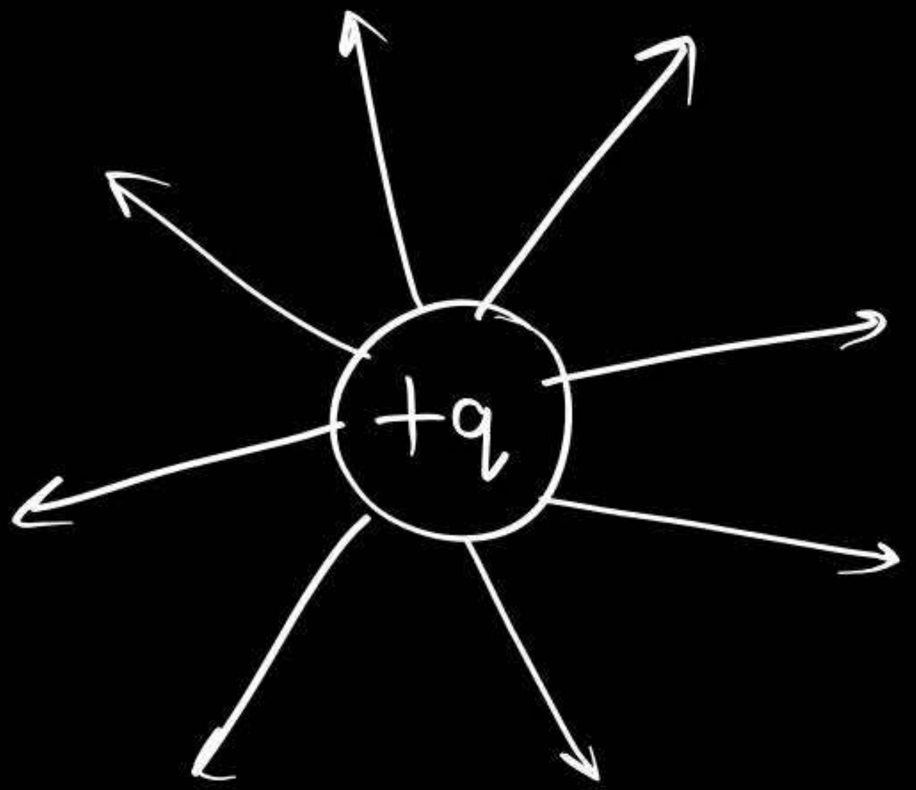
$$(d-x)^2 = 9x^2$$

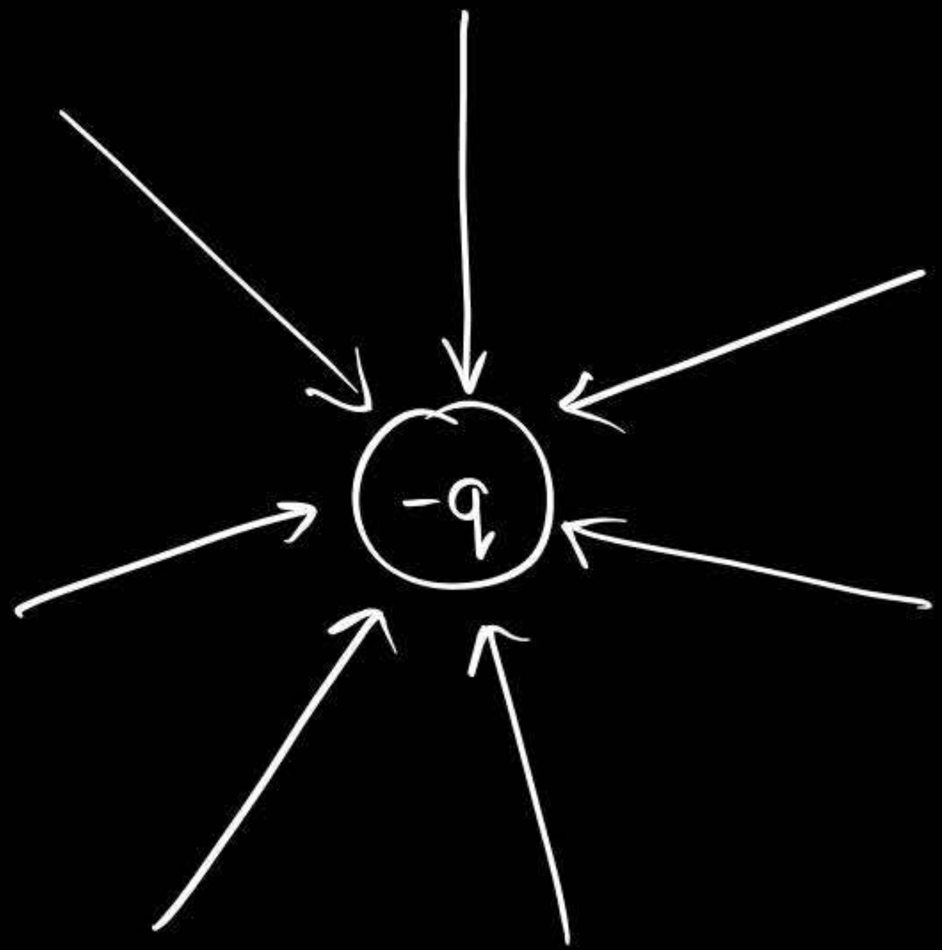
$$(d-x)^2 = (3x)^2$$

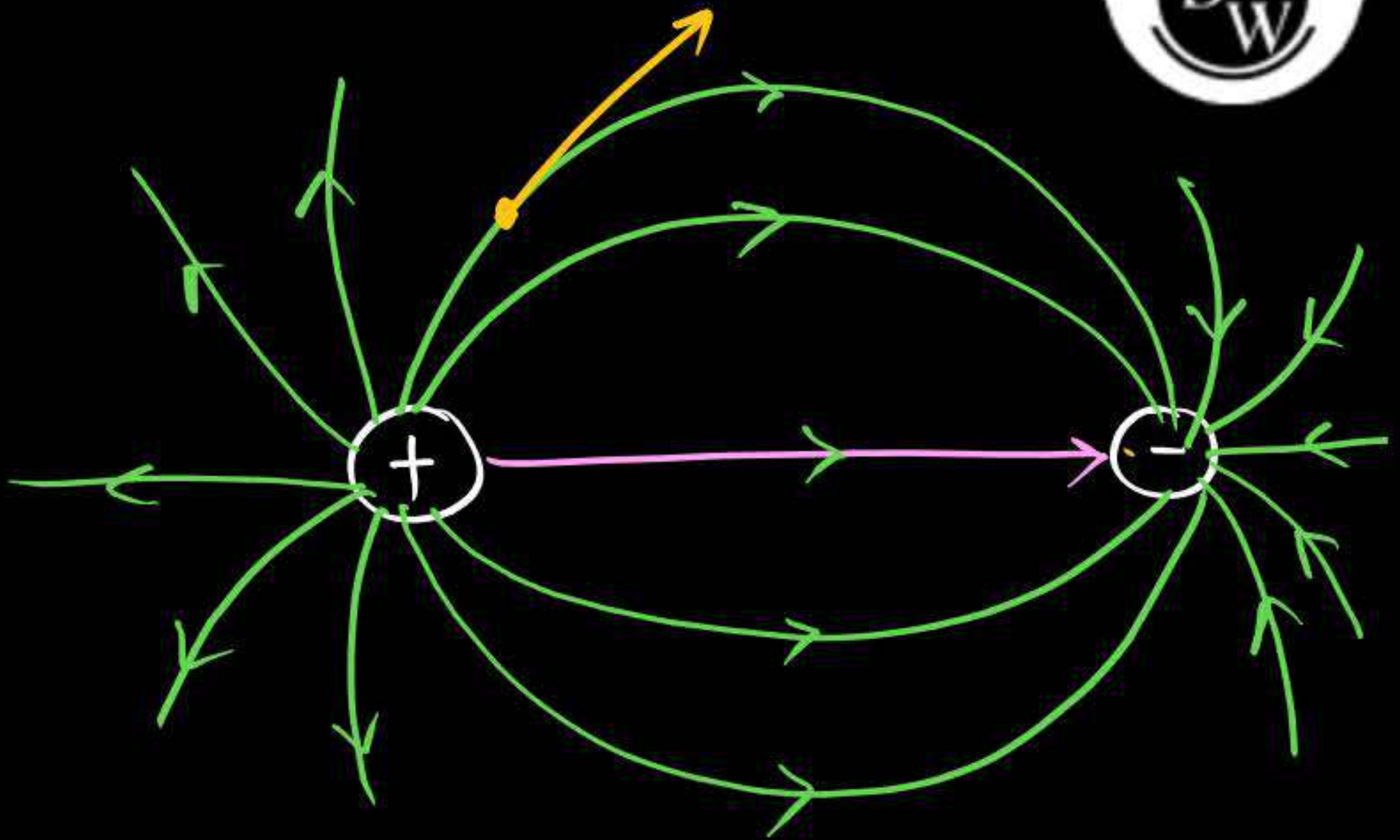
$$d-x = 3x$$

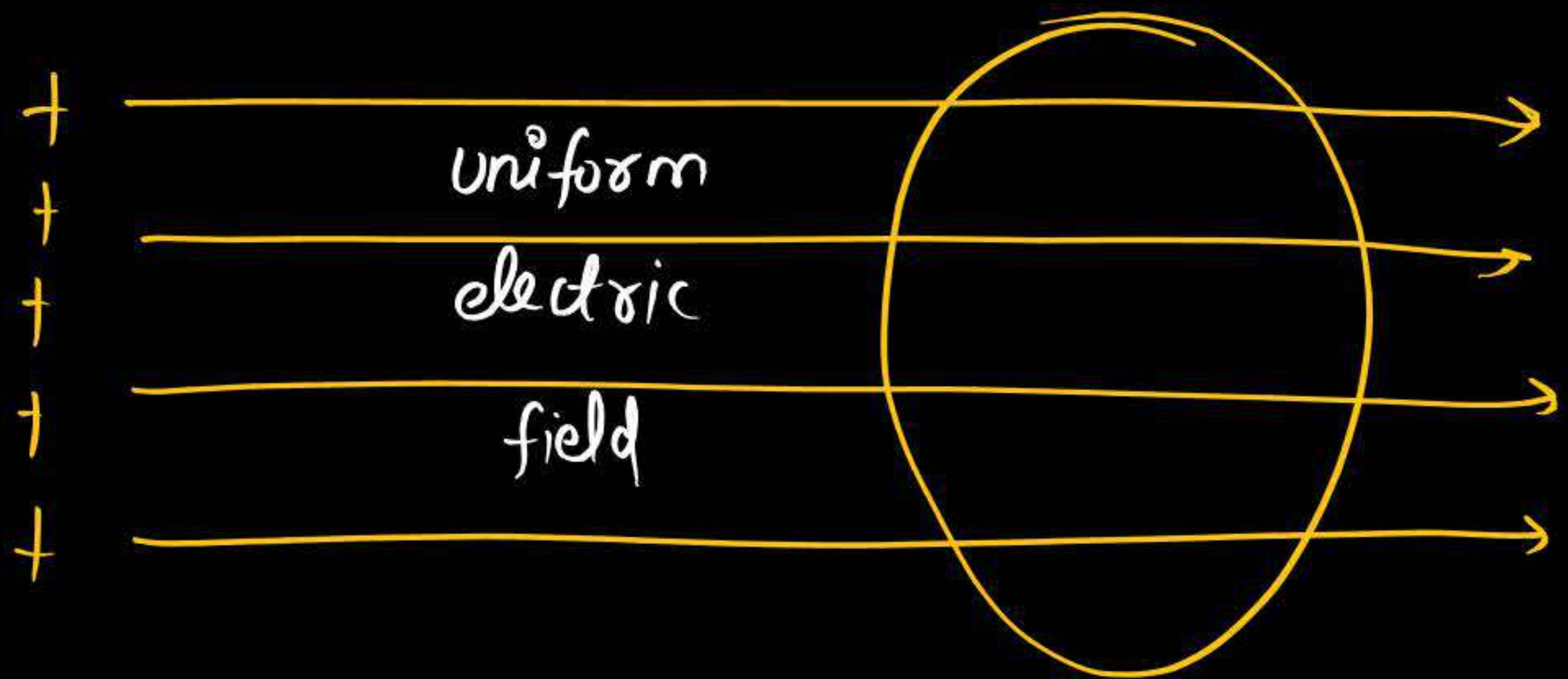
$$d = 3x+x$$

$$d = 4x \Rightarrow x = \frac{d}{4}$$









* imaginary
* Lines of force.
* tangent on lines gives direction of force.

Electric Field Lines

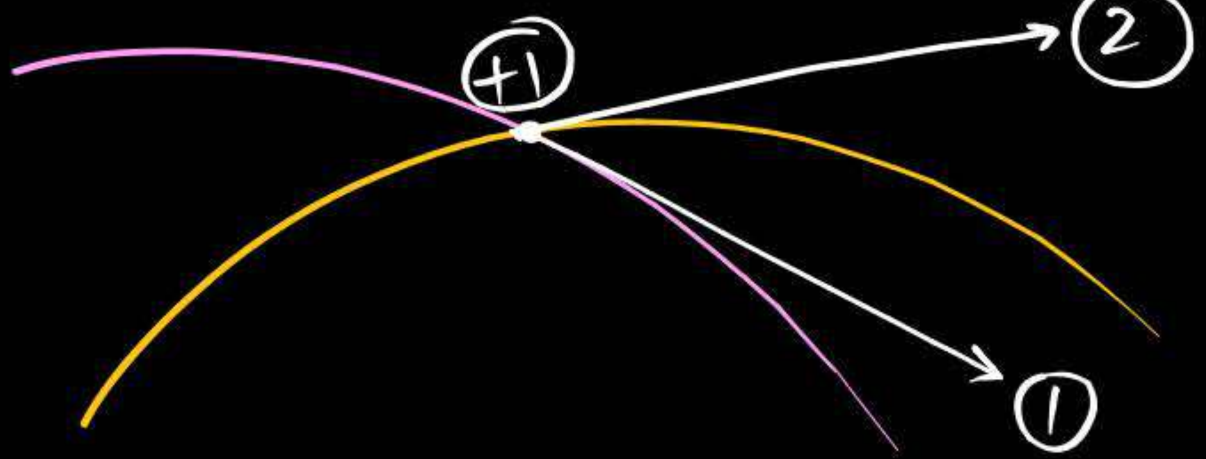
An electric field line is a curve drawn in such a way that tangent to it at each point is in the direction of the net field at that point.

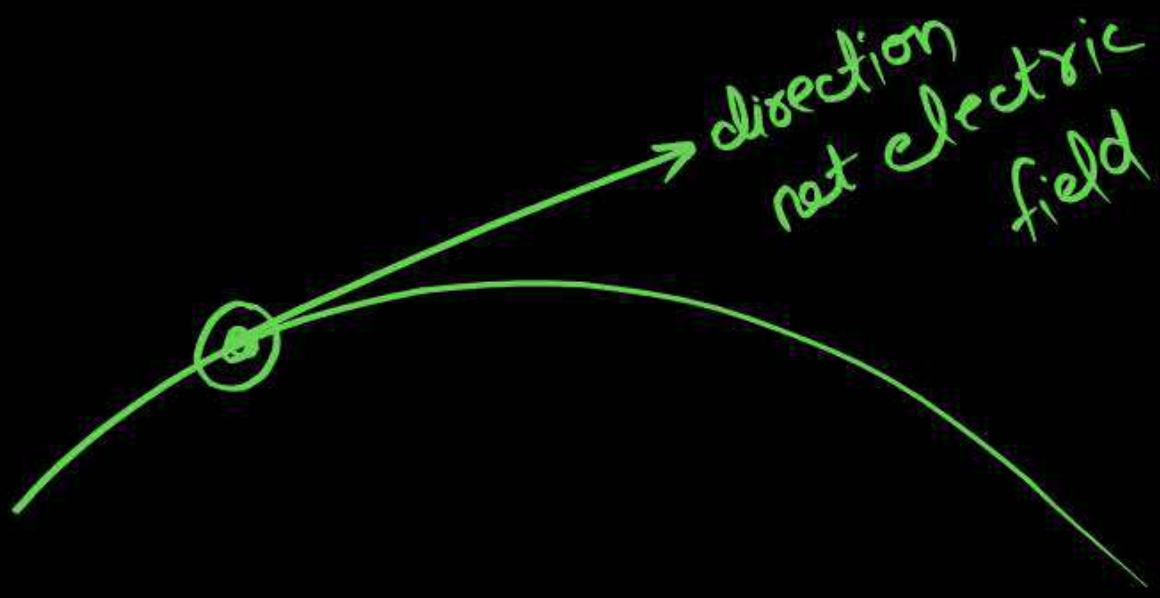
Properties of Electric Field Lines :

1. Field lines start from positive charges and end at negative charges. If there is a single charge, they may start or end at infinity.

2. In a charge-free region, electric field lines can be taken to be continuous curves without any breaks.

3. No two electric field lines can intersect each other because if they do so, then two tangents can be drawn at the point of intersection; which would mean two directions of electric field strength at one point and that is impossible.



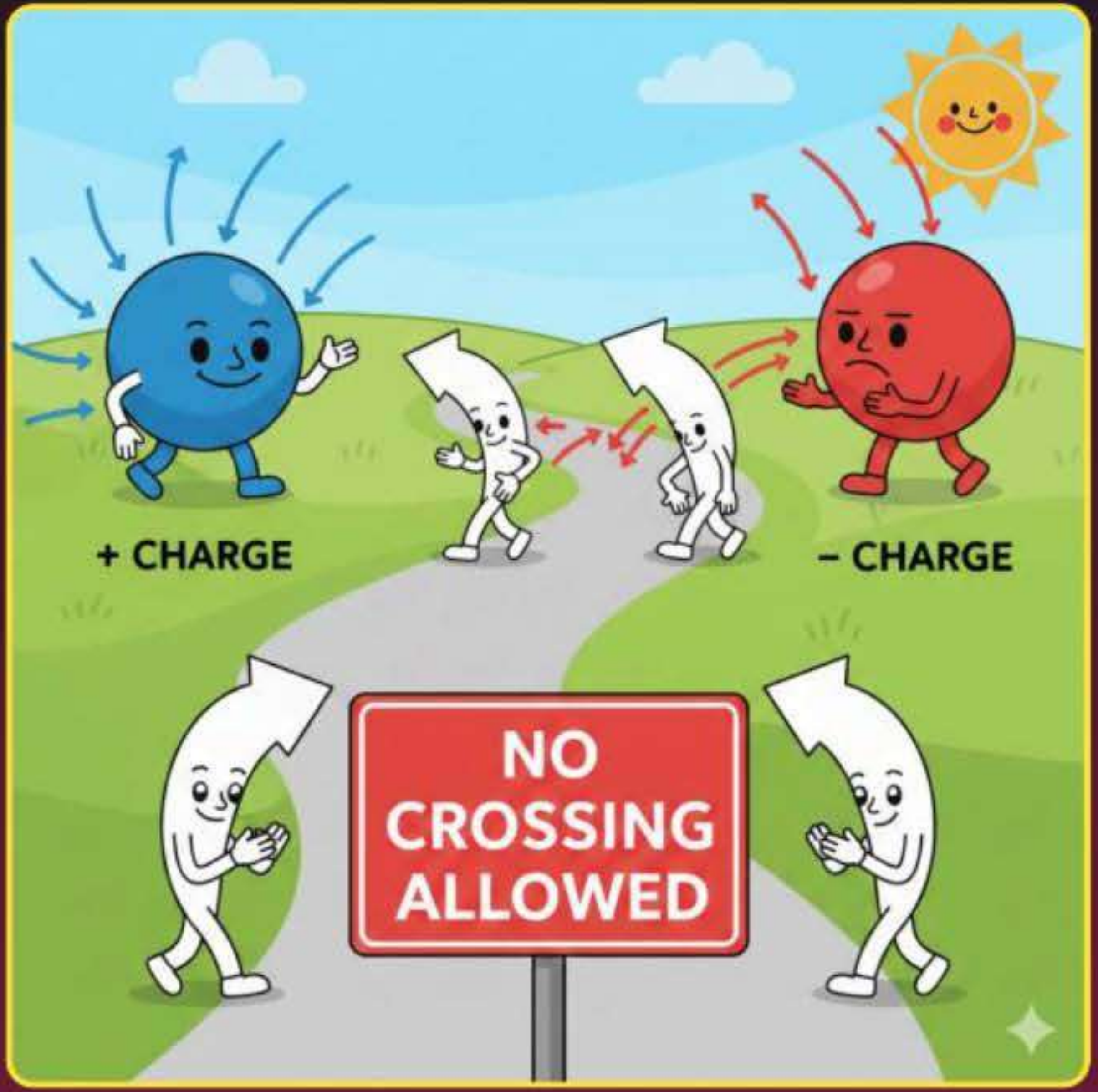


Direction of net field
can't be in two directions

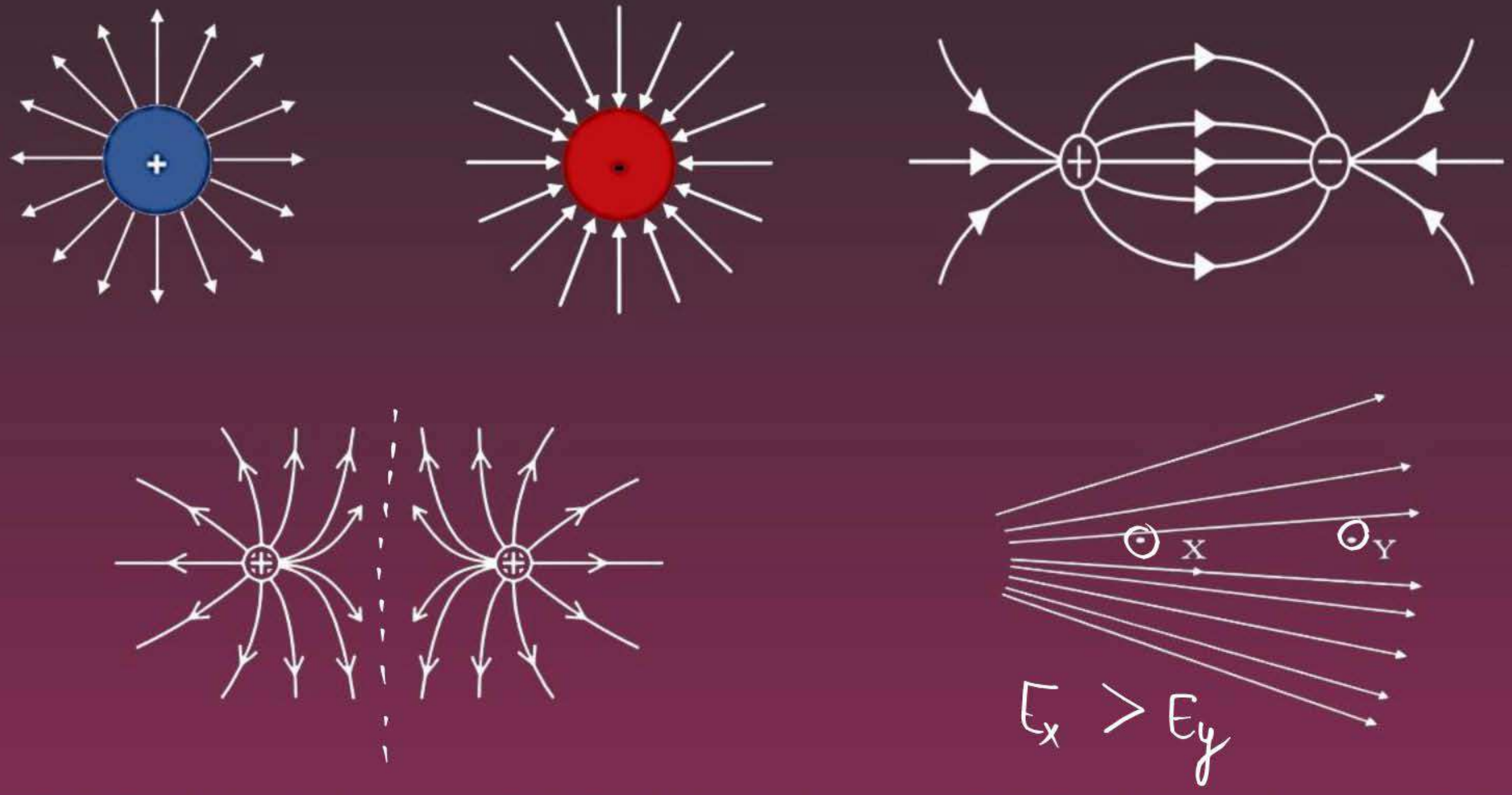
4. The electric field lines do not form any closed loops. This follows from the conservative nature of electric field.

5. The equidistant electric field lines represent uniform electric field while electric field lines at different separations represent non-uniform electric field.

6. More the field lines, higher the electric field at that point.

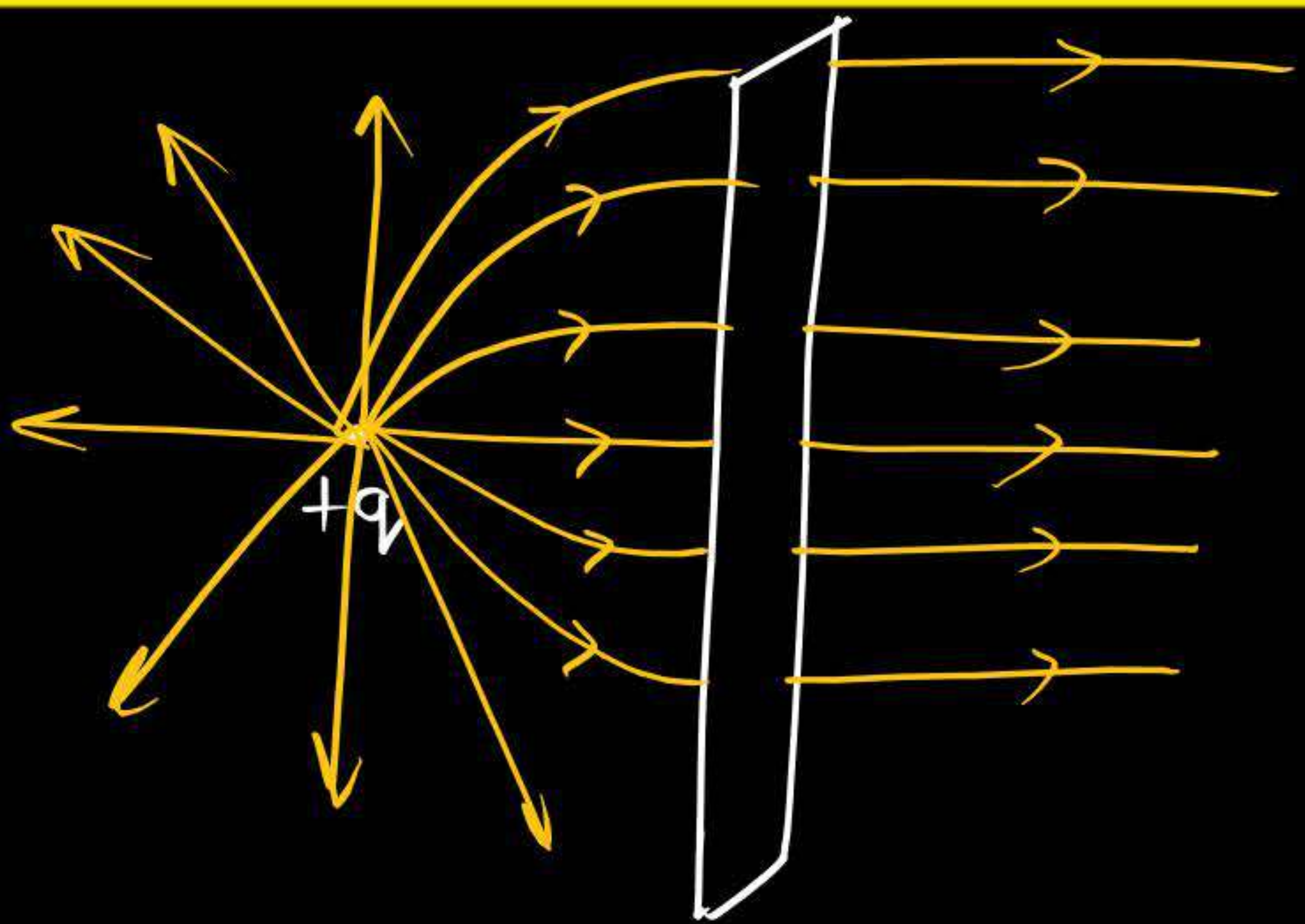


Electric Field Lines



Draw the pattern of electric field lines when a point charge +q is kept near an uncharged conducting plate.

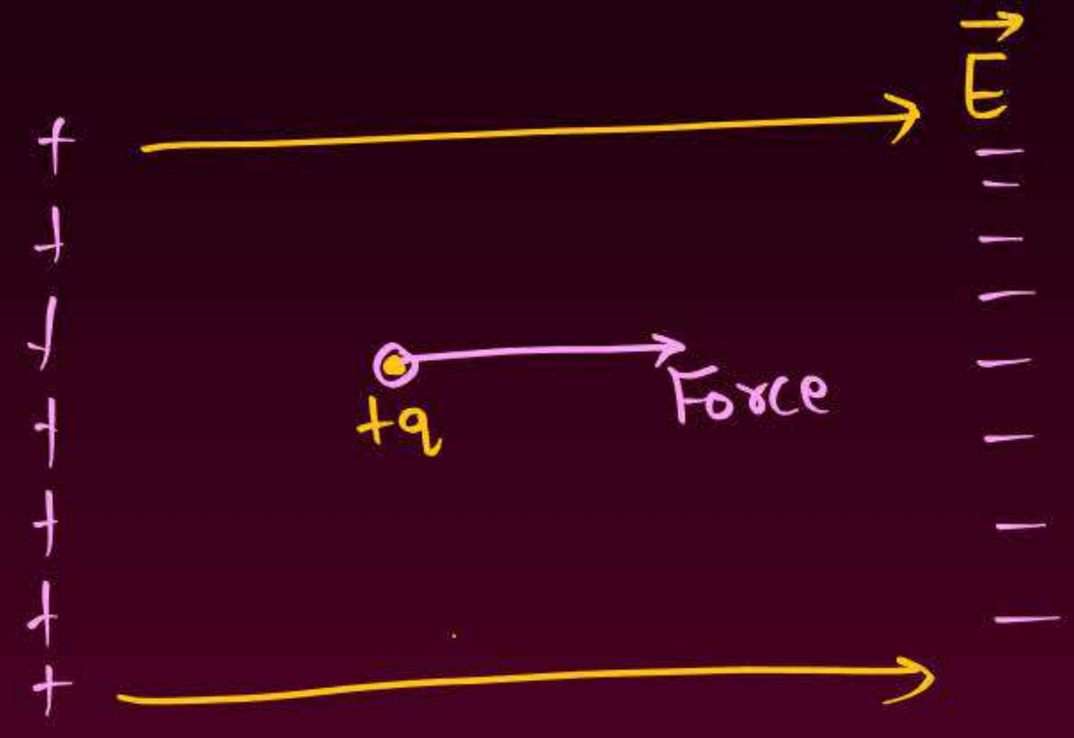
(2019)



Force on Charge Particle in Electric Field

If a charged particle enters in an electric field, it experiences force which can be stated

$$F = qE$$



also,

$$\boxed{ma = qE}$$

$F = qE$

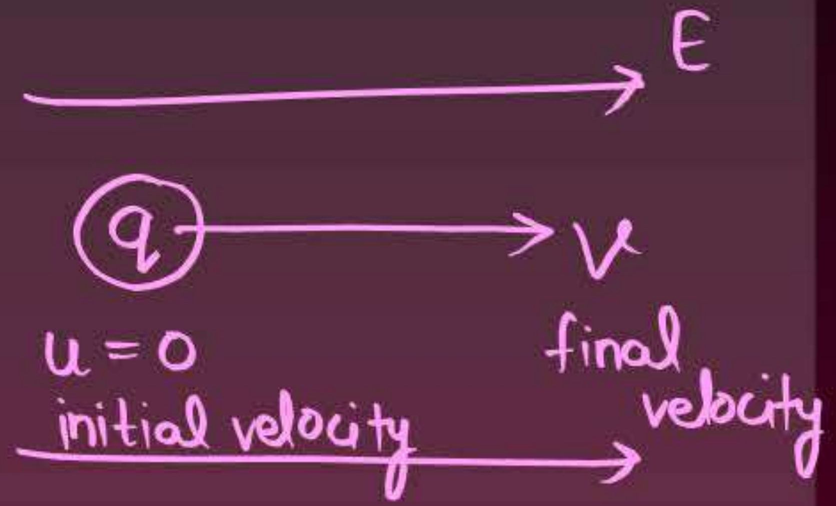
$F = ma$

Acceleration of charged particle

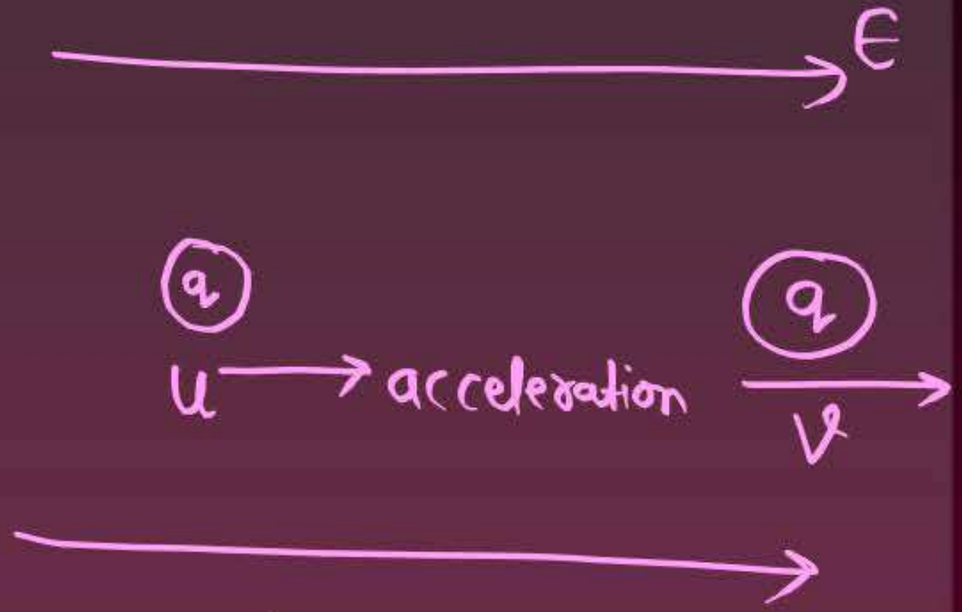
$$\boxed{a = \frac{qE}{m}}$$

Motion of Charge Particle in Electric Field

Charge particle intially at rest

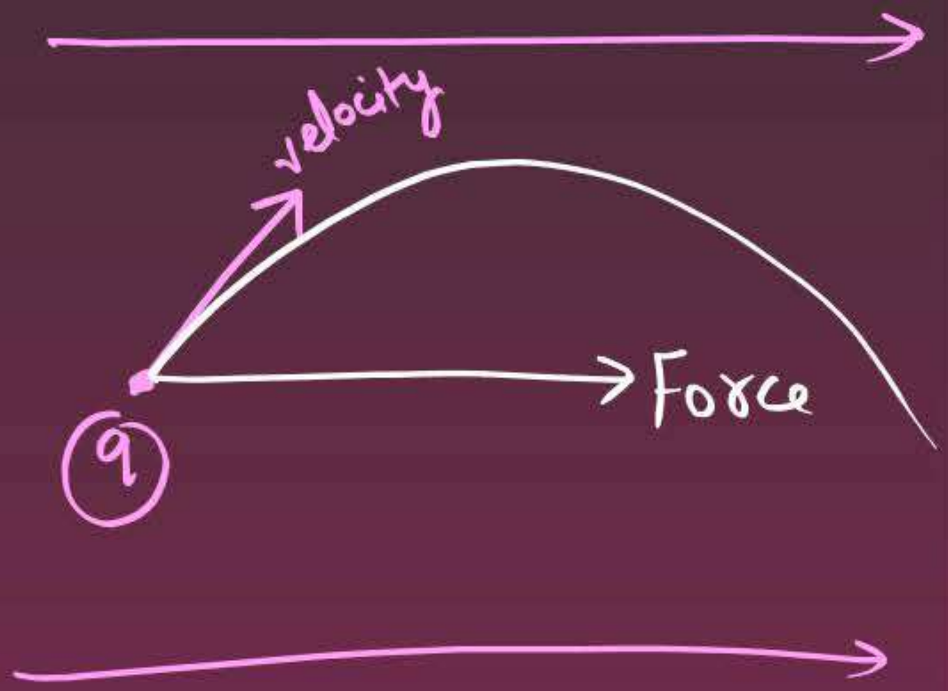


Charge particle projected along Electric Field



along the Electric field

Charge particle projected at some angle to electric field



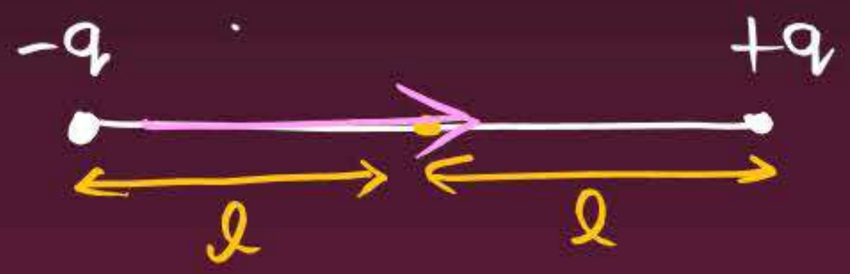
parabolic path

Electric Dipole

A system containing two equal and opposite charges separated by a finite distance is called an electric dipole.

Dipole moment of electric dipole having charges +q and -q at separation 2l is defined as the product of magnitude of one of the charges and shortest distance between them.

$$\vec{p} = q2\vec{l}$$



It is a vector quantity, directed from -q to +q.

$$\boxed{\vec{p} = q(2\vec{l})}$$

$2\vec{l}$ → separation

SI unit is Cm.

⇓

Coulomb metre

Two charged particles P and Q, having the same charge but different masss m_P and m_Q start from rest and travel equal distances in a uniform electric field E in time t_P and t_Q respectively. Neglecting the effect of gravity, the ratio $\left(\frac{t_P}{t_Q}\right)$ is

$\left(s = ut + \frac{1}{2}at^2\right)$ if $u=0 \Rightarrow s = \frac{1}{2}at^2$

(2024)

A $\frac{m_P}{m_Q}$

B $\frac{m_Q}{m_P}$

C $\sqrt{\frac{m_P}{m_Q}}$ ✓

D $\sqrt{\frac{m_Q}{m_P}}$

P: m_P, $u=0$

Q: m_Q, $u=0$

initial velocity

$a_P = \frac{qE}{m_P}$ $\quad a_Q = \frac{qE}{m_Q}$

$s_P = s_Q$

$\cancel{\frac{1}{2}}a_P t_P^2 = \cancel{\frac{1}{2}}a_Q t_Q^2$

$\frac{\cancel{qE}}{m_P} t_P^2 = \frac{\cancel{qE}}{m_Q} t_Q^2$

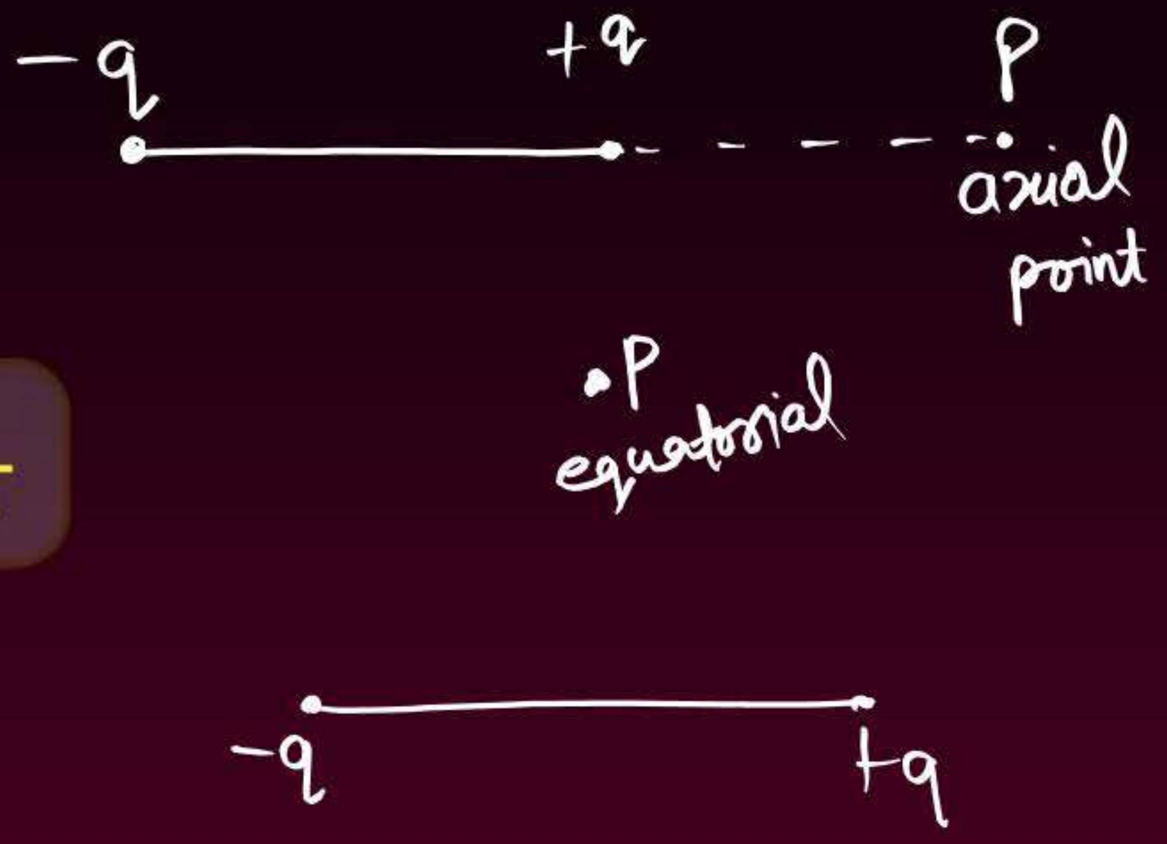
$\frac{t_P^2}{t_Q^2} = \frac{m_P}{m_Q}$

$\frac{t_P}{t_Q} = \sqrt{\frac{m_P}{m_Q}}$

Electric Field Due to a Short Dipole

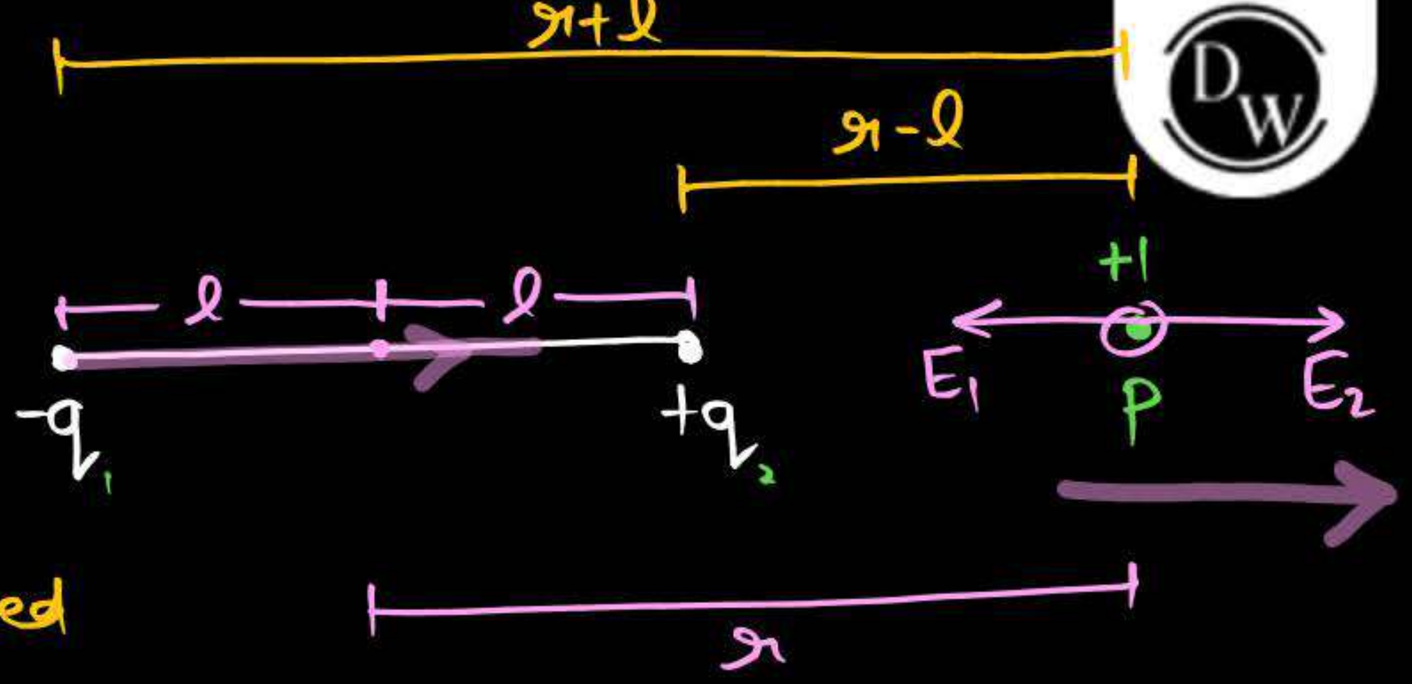
I. At a point P on axis, $E = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$

II. At a point P' on equatorial line, $E' = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}$



① Electric field at axis of dipole :

Let's take a dipole having separation $2l$.



To find the Electric dipole at point 'P', placed a test charge +1 ; Now,

$$E_1 = |E_1| = \frac{kq_1}{(r+l)^2} \quad \text{---} ①$$

$$E_2 = |E_2| = \frac{kq}{(r-l)^2} \quad \text{---} ②$$

$$E_{net} = E_2 - E_1$$

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

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

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

$$= kq\left[\frac{(r+l)^2 - (r-l)^2}{(r-l)^2\,(r+l)^2}\right]$$

$$= kq\,\frac{\left[r^2+l^2+2rl-(r^2+l^2-2rl)\right]}{\left[(r-l)(r+l)\right]^2}$$

$$= kq\left[\frac{\cancel{r^2}+\cancel{l^2}+2rl-\cancel{r^2}-\cancel{l^2}+2rl}{(r^2-l^2)^2}\right]$$

$$E_{net} = \frac{kq\cdot 4rl}{(r^2-l^2)^2}$$

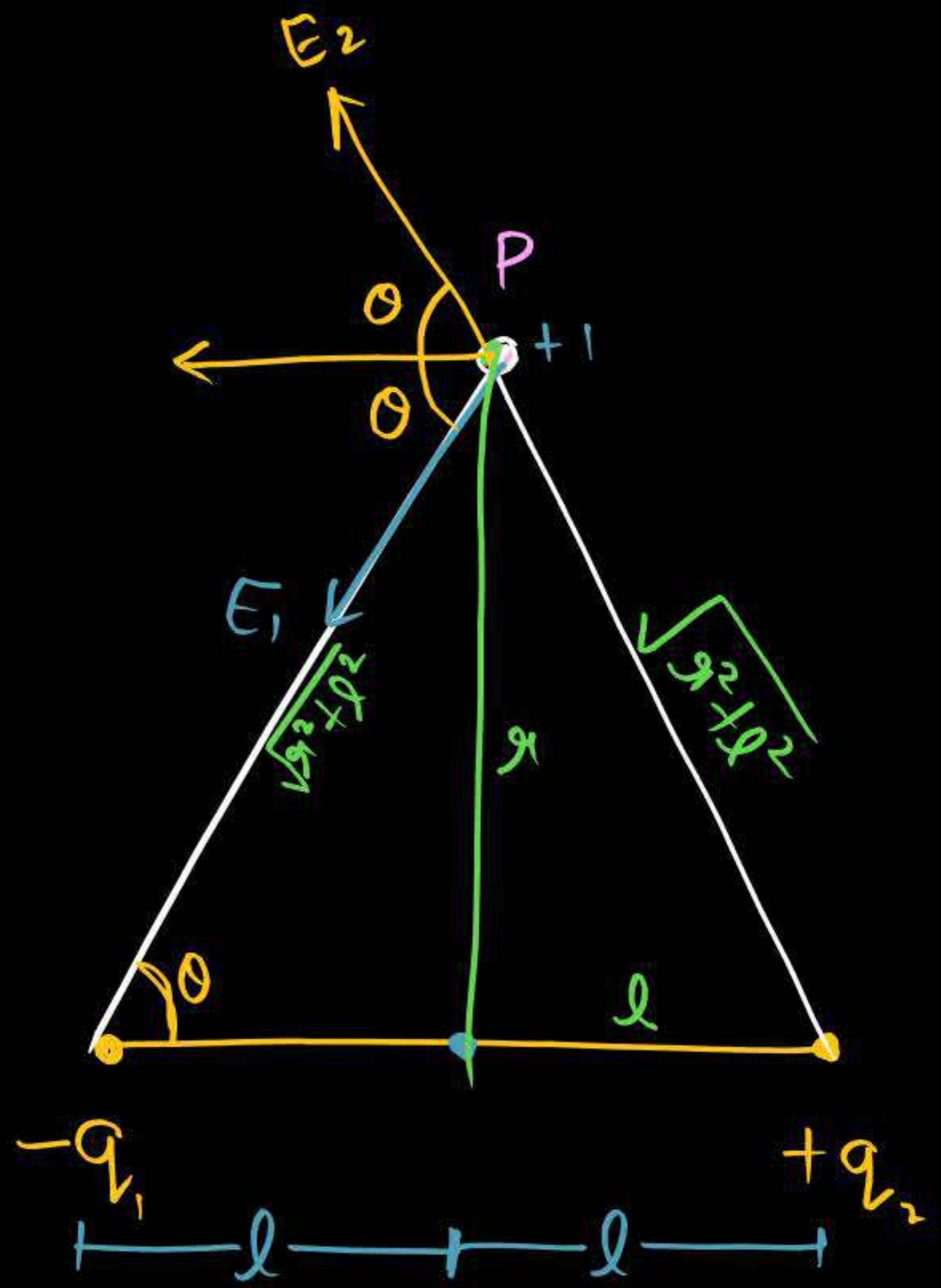
$$= \frac{2\times 2\,kq\,rl}{(r^2-l^2)^2}$$

$$\boxed{E_{net} = \frac{2kpr}{(r^2-l^2)^2}}$$

If dipole is ideal $r >>> l$

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

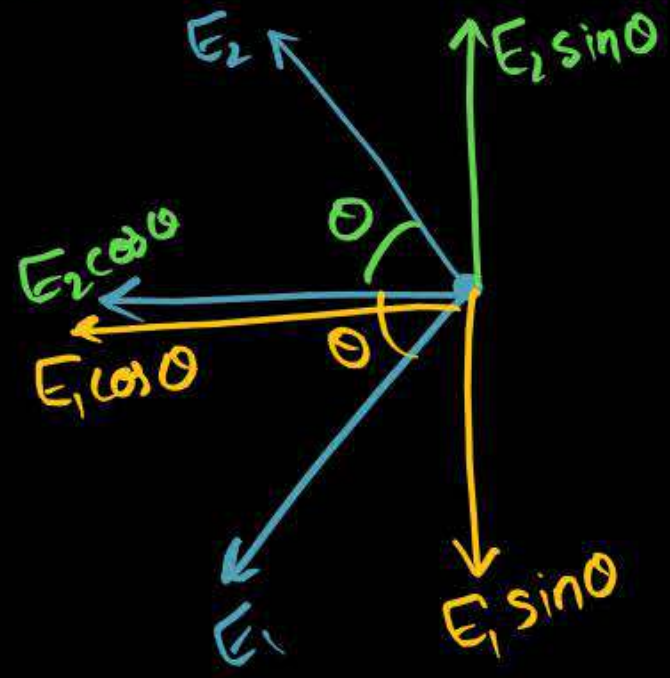
(2) At equatorial line :



let's take a dipole having separation 2l

To find E_{net} at point P,

As we can see $E_1 = E_2 = E$



components $E_2 \sin\theta$ and $E_1 \sin\theta$ will cancel out

$$E_{net} = E_1 \cos\theta + E_2 \cos\theta$$

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

$$= 2 \times \frac{kq}{\left(\sqrt{r^2+l^2}\right)^2} \cos\theta$$

$$E_{net} = \frac{2kq}{r^2+l^2} \times \frac{l}{\sqrt{r^2+l^2}}$$

$$E_{net} = \frac{kp}{(r^2+l^2)^1 \, (r^2+l^2)^{1/2}}$$

$$\boxed{E_{net} = \frac{kp}{(r^2+l^2)^{3/2}}}$$

If dipole is ideal

$r >>> l$

$$E_{net} = \frac{kp}{(r^2+0^2)^{3/2}}$$

$$= \frac{kp}{(r^2)^{3/2}}$$

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

Consider two identical dipoles D_1 and D_2. Charges $-q$ and $+q$ of dipole D_1 are located at (0, 0) and (a, 0) and that of dipole D_2 at (0, a) and (0, 2a) in the XY-plane, respectively. The net dipole moment of the system is

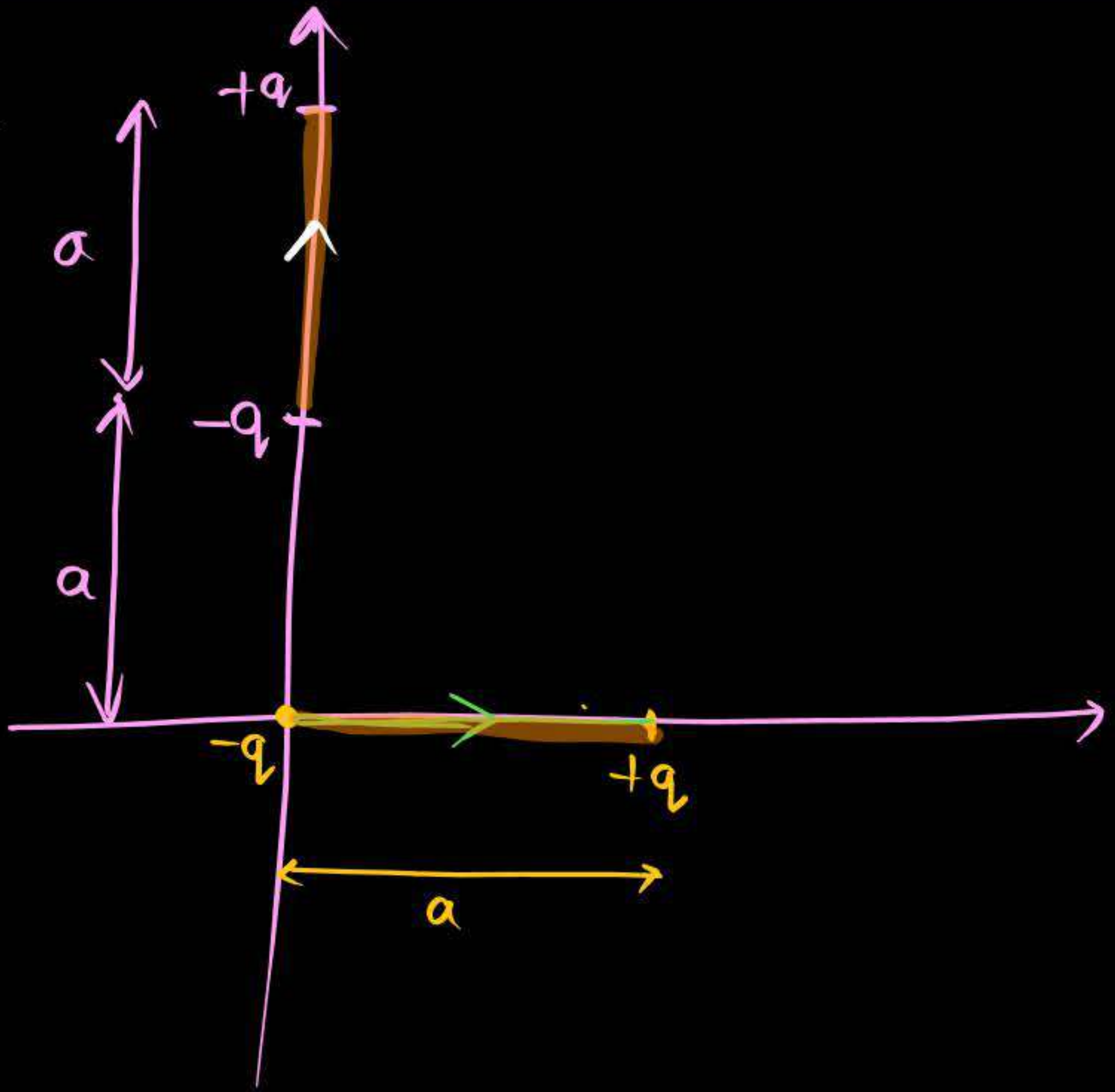
(CBSE 2025)

A) $qa(\hat{i} + \hat{j})$

B) $-qa(\hat{i} + \hat{j})$

C) $qa(\hat{i} - \hat{j})$

D) $-qa(\hat{i} - \hat{j})$



$$\vec{p}_1 = qa\hat{i}$$

$$\vec{p}_2 = qa\hat{j}$$

$$\vec{p} = \vec{p}_1 + \vec{p}_2$$

$$= qa\hat{i} + qa\hat{j}$$

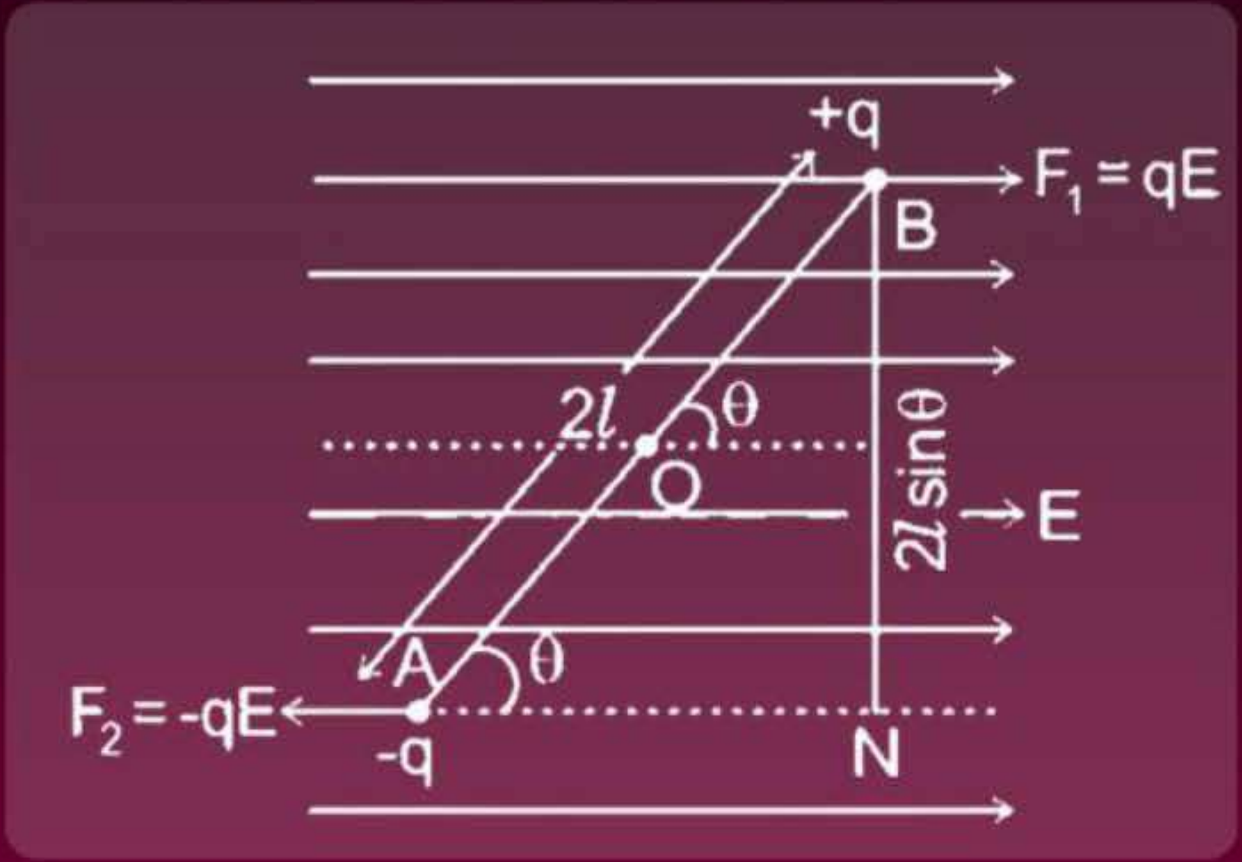
$$= qa(\hat{i} + \hat{j})$$

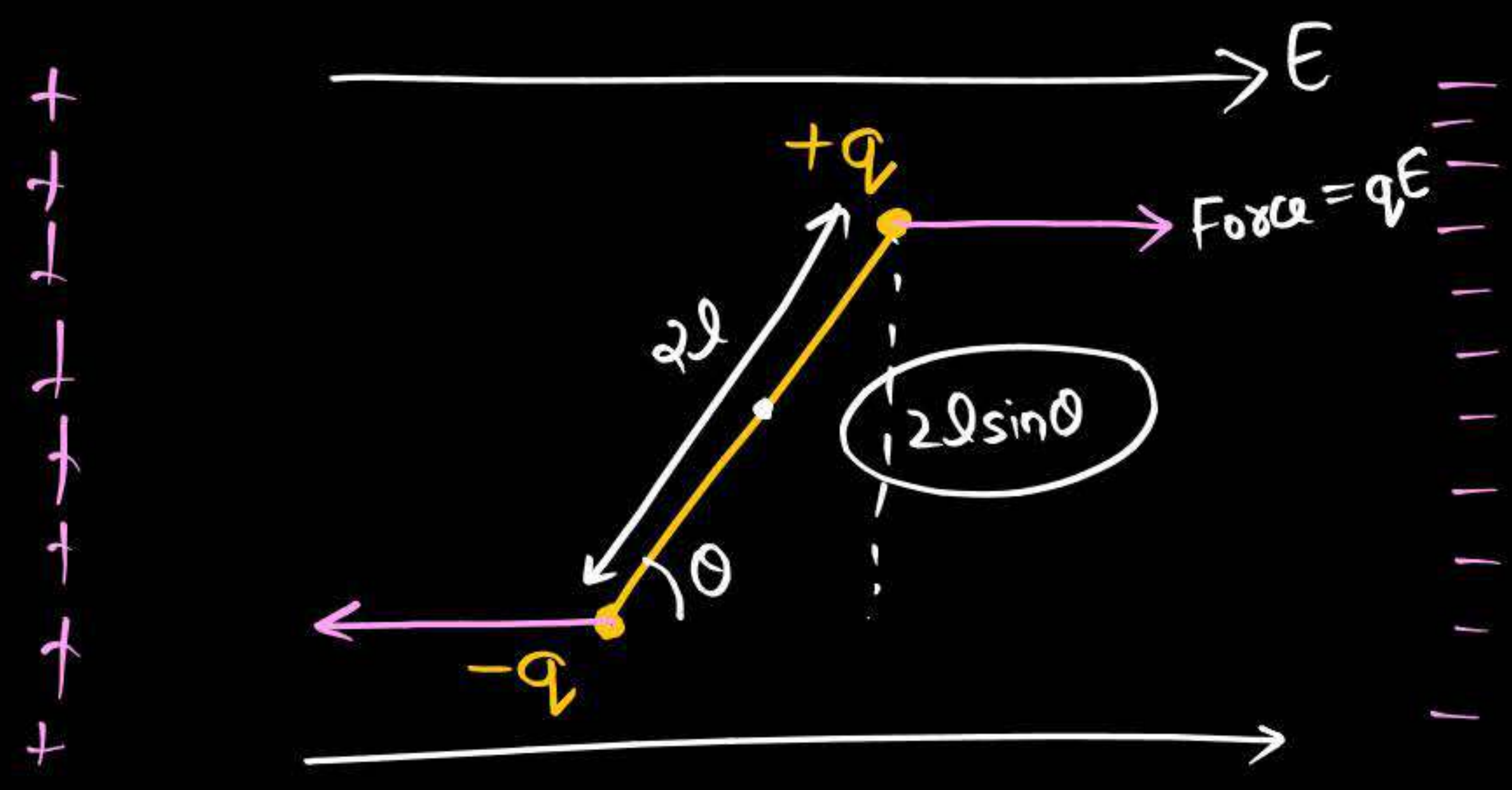
Electric Force and Torque on an Electric Dipole in a Uniform Electric Field

I. In a uniform electric field of strength E, the net electric force is zero; but a torque equal to pEsin θ acts on the dipole (where θ is the angle between directions of dipole moment $\vec{p}$ and electric field $\vec{E}$).

II. This torque tends to align the dipole along the direction of electric field.

III. Torque in vector form $\vec{\tau} = \vec{p} \times \vec{E}$.





Torque = Force × perpendicular distance

$$\tau = qE \times 2l\sin\theta$$

$$\boxed{\tau = pE\sin\theta} \Rightarrow \theta = 90^\circ$$

$\boxed{\tau = \text{maximum}}$

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

$\theta = 0$

direction $\vec{p}$ and $\vec{E}$ same

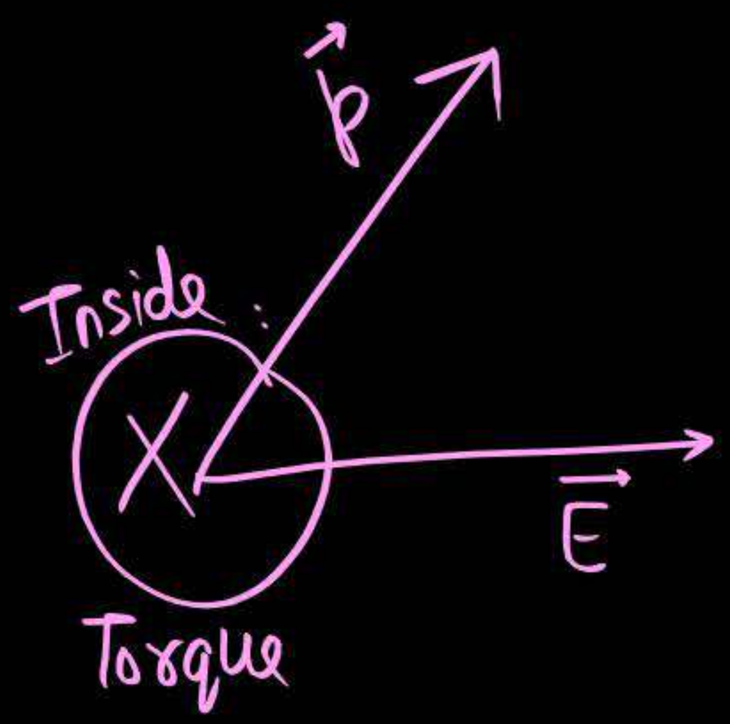
$\tau = 0$ (stable equilibirium)

$\theta = 180^\circ$

$\vec{p}$ and $\vec{E}$ opposite

$\tau = 0$

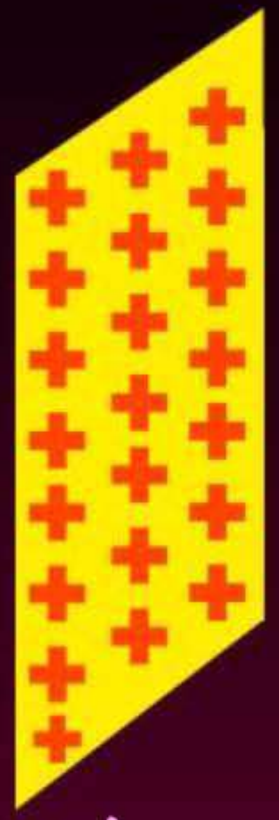
(unstable equilibirium)



Continuous Charges Distributions

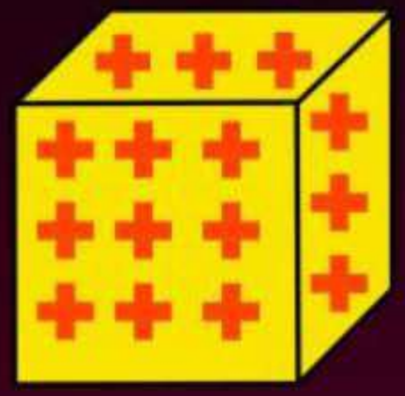
Linear charge density

$$\boxed{\lambda = \frac{q}{l}}$$



Surface charge density

$$\boxed{\sigma = \frac{q}{\text{Area}}}$$



Volume charge density

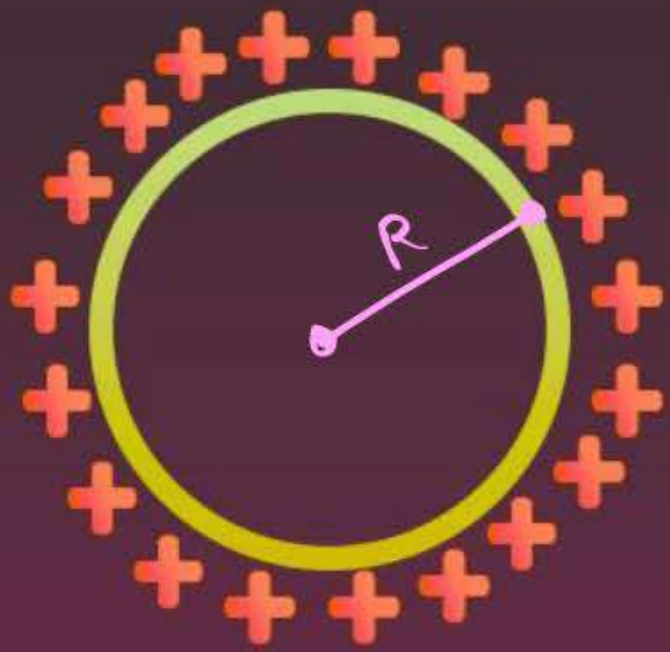
$$\boxed{\rho = \frac{q}{\text{Volume}}}$$

Electric Field due to Ring & arc

(1) At Centre

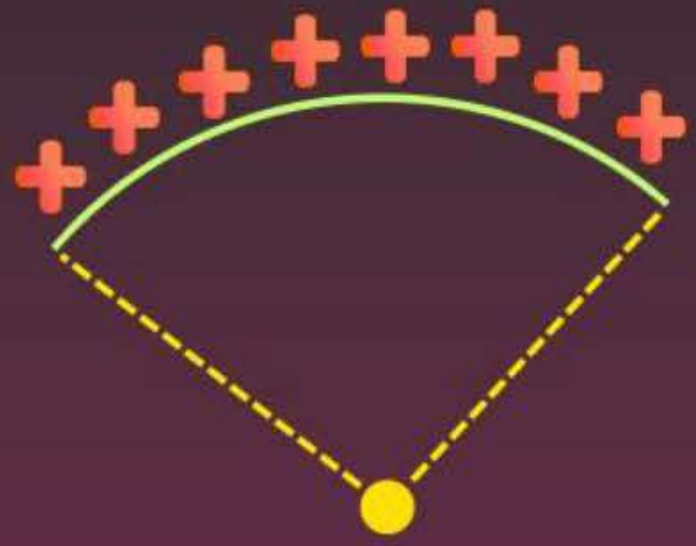
$$\boxed{E_{net} = 0}$$

(2) At Surface

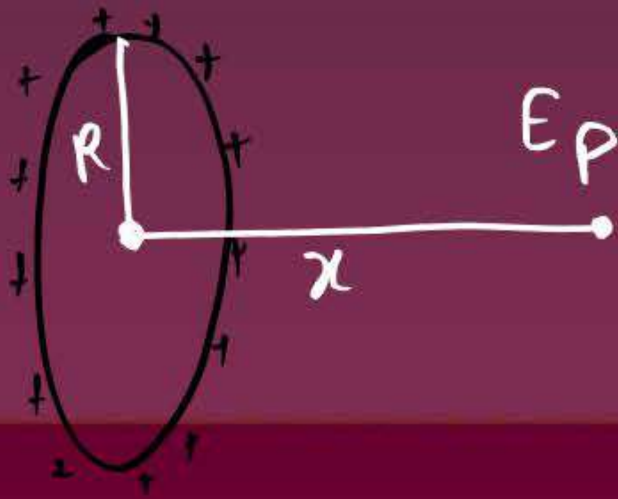


$$\boxed{E = \frac{KQ}{R^2}}$$

(3) Arc centre



$$E = \frac{2k\lambda}{R} sin\frac{\theta}{2}$$



$$E_P = \frac{KQx}{(R^2+x^2)^{3/2}}$$

Electric Flux

The total number of electric field lines crossing (or diverging) a surface normally is called electric flux.

Electric flux through surface element d is $\Delta\phi = \vec{E}\cdot d\vec{S} = E\,dS\cos\theta$

where $\vec{E}$ is electric field strength.

Electric flux through entire closed surface is $\phi = \oint_S \vec{E}\cdot d\vec{S}$

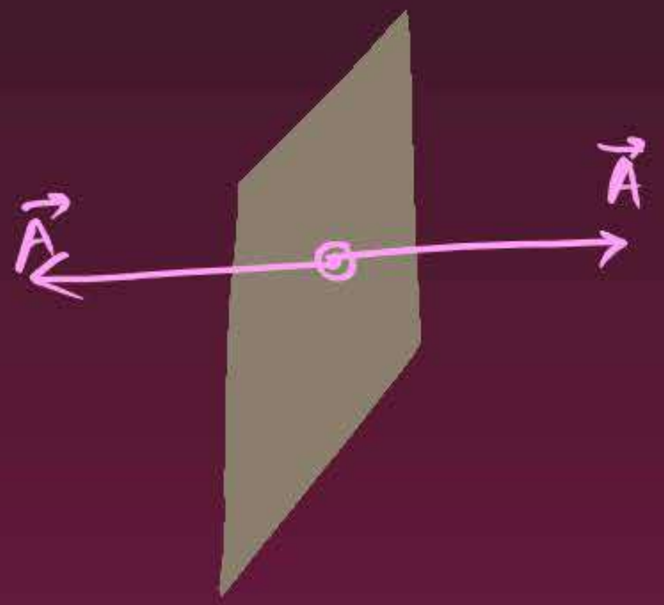
SI unit of electric flux is volt-metre or $Nm^2\,C^{-1}$.

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

$\Downarrow$

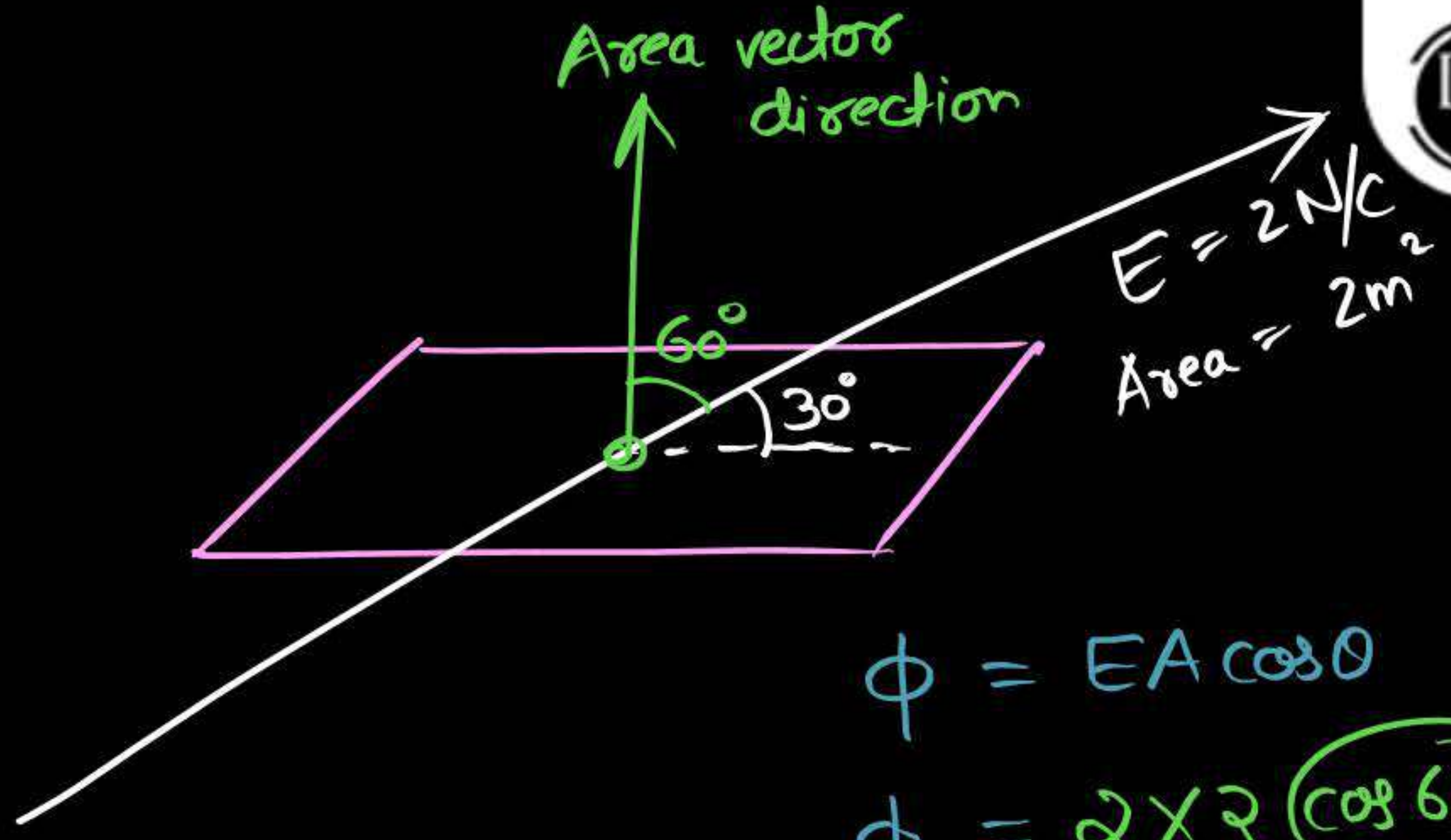
scalar

$\boxed{\phi = EA\cos\theta}$



$$\int d\phi = \int E \, dA \cos\theta$$

$$\phi = \int E \, dA \cos\theta$$



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

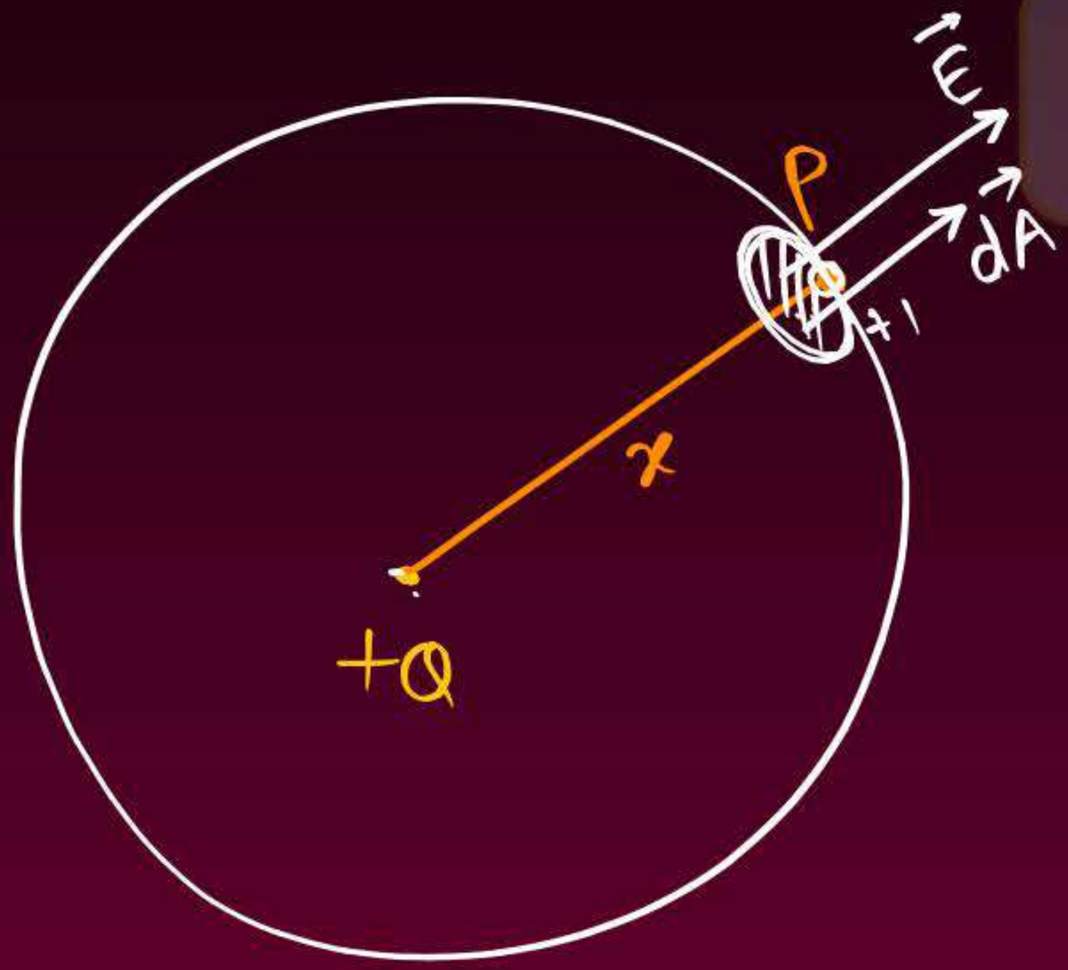
$$\phi = 2 \times 2 \cos 60^\circ$$

$$= 2 \times 2 \times \frac{1}{2}$$

$$\phi = 2 \ Nm^2/C$$

Gauss's Theorem

It states that the total electric flux through a closed surface is equal to $1/\varepsilon_0$ times the net charge enclosed by the surface enclosed by the surface



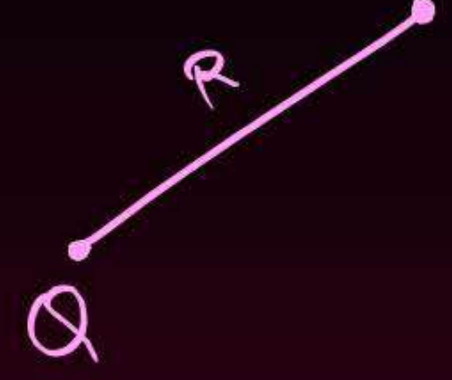
$$\phi = \oint_S \vec{E} \cdot d\vec{S} = \frac{1}{\varepsilon_0} \Sigma q$$

$$\phi = \oint \vec{E}\, d\vec{A} = \frac{1}{\varepsilon_0} \times q_{in}$$

$$\boxed{\oint E\, dA \cos\theta = \frac{q_{in}}{\varepsilon_0}}\ *$$

Appication of Gauss's Theorem

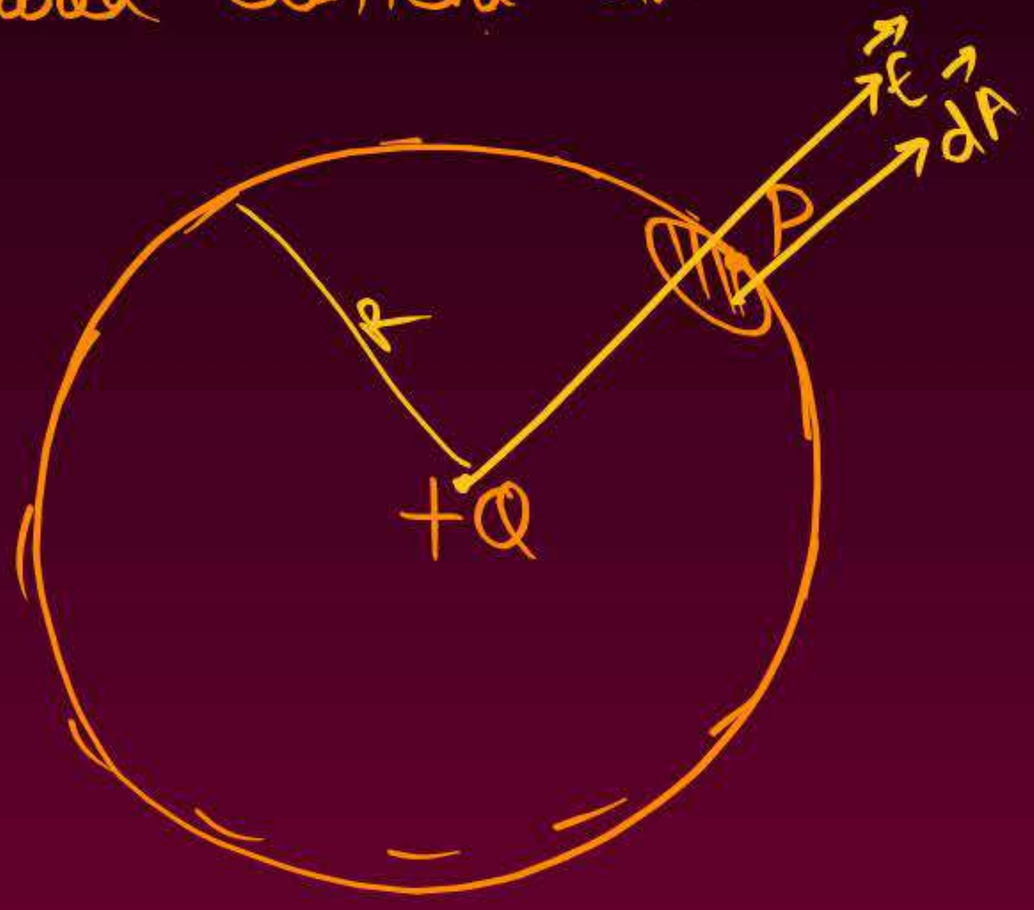
$E_P = \frac{KQ}{R^2}$



1. **Electric Field due to a point charge at distance R.**

To find Electric field at point P.

Draw a spherical gaussian surface and take an area element dA at P.



Using Gauss theorem

$$\oint \vec{E}\cdot d\vec{A} = \frac{q_{in}}{\varepsilon_0}$$

$$\oint E\,dA\cos 0^\circ = \frac{Q}{\varepsilon_0}$$

$$E\int dA = \frac{Q}{\varepsilon_0}$$

$$E\,4\pi R^2 = \frac{Q}{\varepsilon_0}$$

$$E = \frac{1}{4\pi R^2}\,\frac{Q}{\varepsilon_0}$$

$$E = \frac{1}{4\pi\varepsilon_0}\,\frac{Q}{R^2}$$

$$\boxed{E = \frac{KQ}{R^2}}$$

A point charge causes an electric flux of -2×10^4 N m^2 C^{-1} to pass through a spherical Gaussian surface of 8.0 cm radius, centred on the charge. The value of the point charge is:

Given $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2})

(JEE Mains 2025)

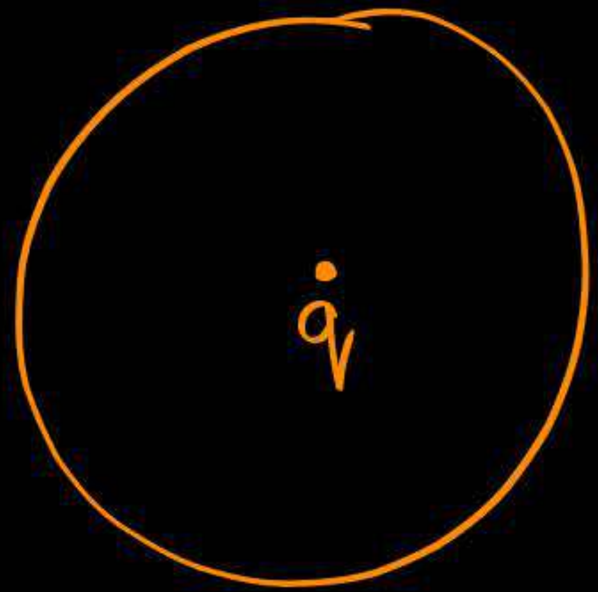
A) 4.0×10^{2} C

B) 2.11×10^{-12} C

C) 1.32×10^{-4} C

D) 1.77×10^{-7} C ✓

$\phi = -2 \times 10^4$ Nm^2/C



$$\phi = \frac{q}{\varepsilon_0}$$

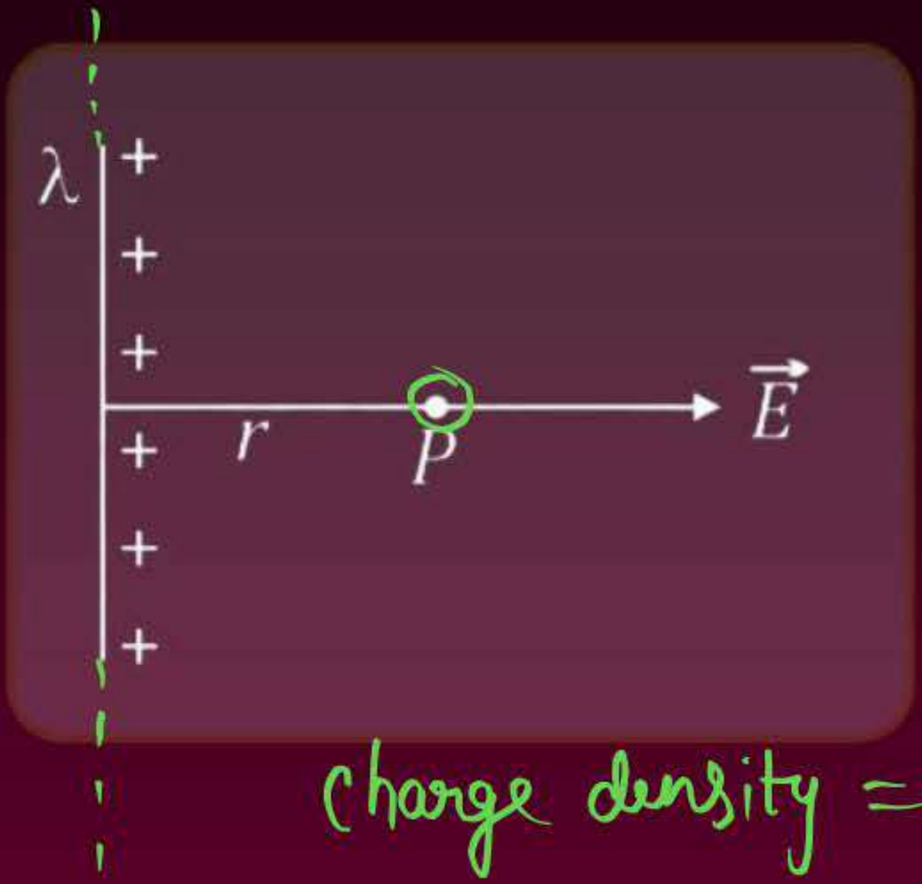
$$-2 \times 10^4 = \frac{q}{8.85 \times 10^{-12}}$$

$$q = -2 \times 10^4 \times 8.85 \times 10^{-12}$$

$$= -1.77 \times 10^{-7}\ C$$

Formulae for Electric Field Strength Calculated From Gauss's Theorem

Electric field due to infinitely long straight wire of charge per unit length λ at a distance r from the wire is

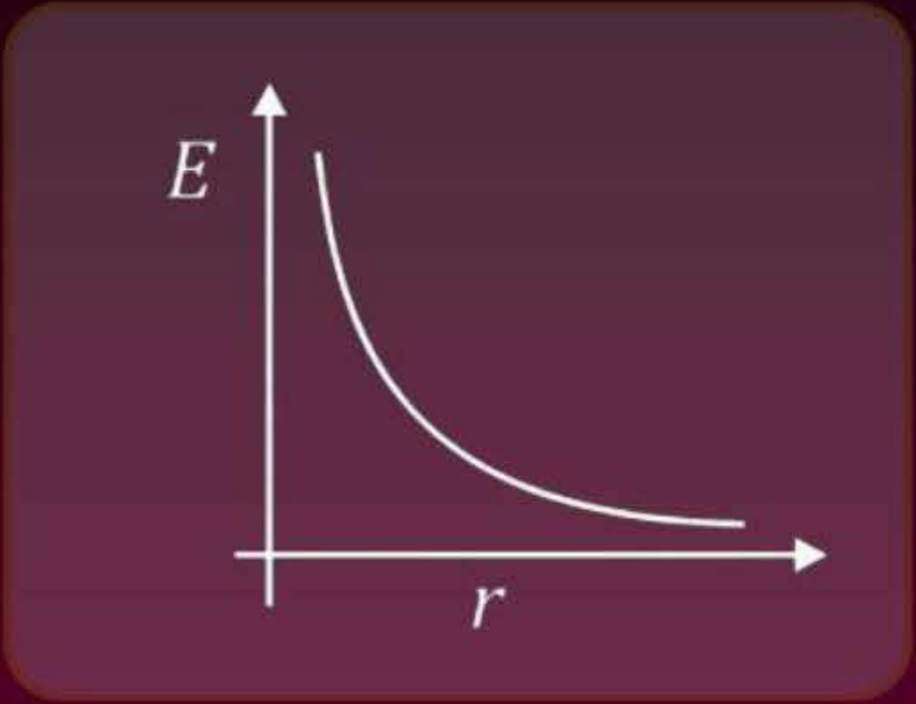


charge density = λ

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

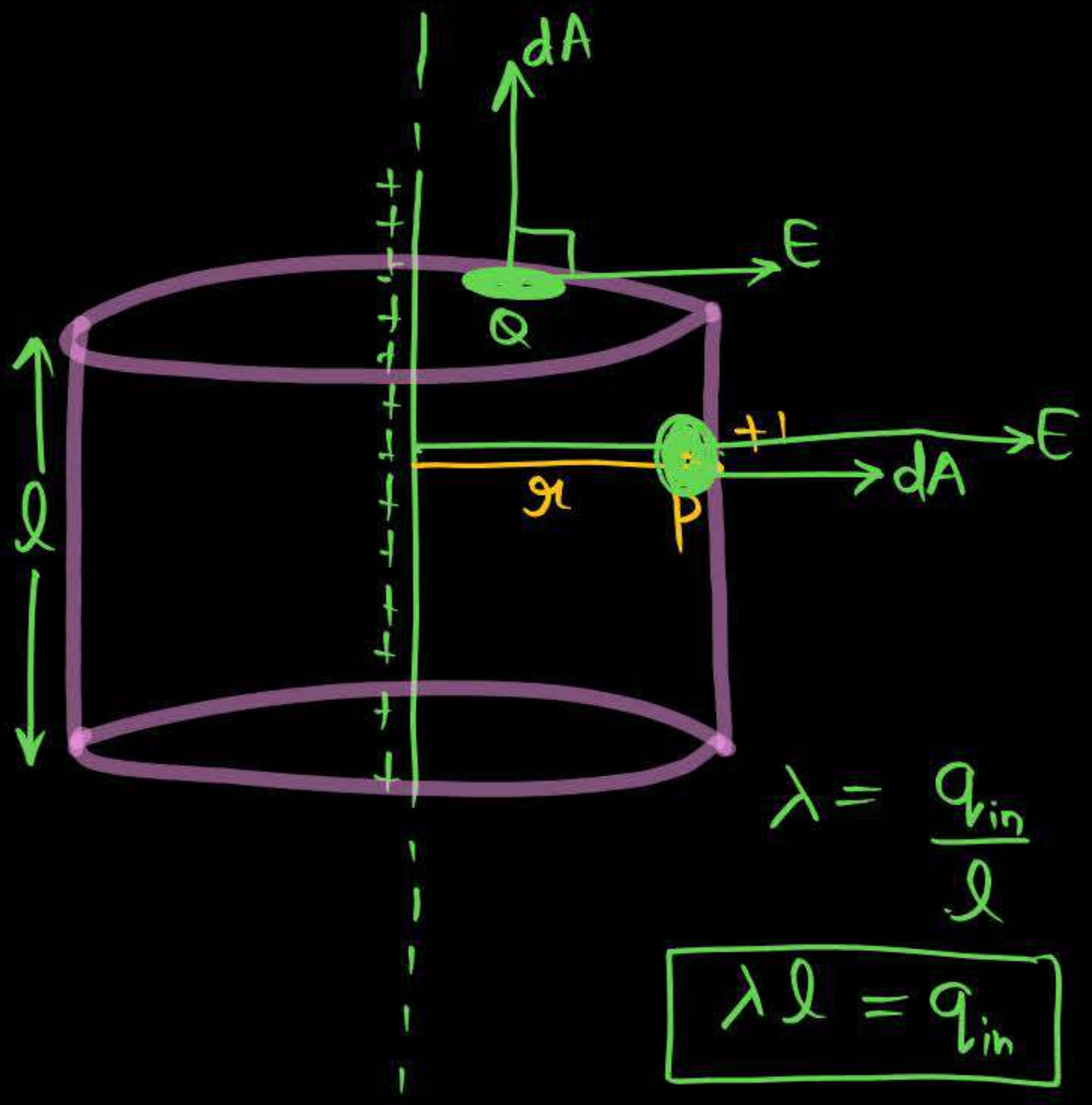
OR

$$E = \frac{\lambda}{2\pi r \varepsilon_0}$$



To find Electric field intensity at point P. Draw a gaussian (cylindrical) surface taking dA element...

Using gauss theorem



$$\lambda = \frac{q_{in}}{l}$$

$$\boxed{\lambda l = q_{in}}$$

$$\oint E \cdot dA \cos 90^\circ + \oint E\, dA \cos 0^\circ = \frac{q_{in}}{\varepsilon_0}$$

$$0 + E \int dA = \frac{\lambda l}{\varepsilon_0}$$

$$E\, 2\pi r \cancel{l} = \frac{\lambda \cancel{l}}{\varepsilon_0}$$

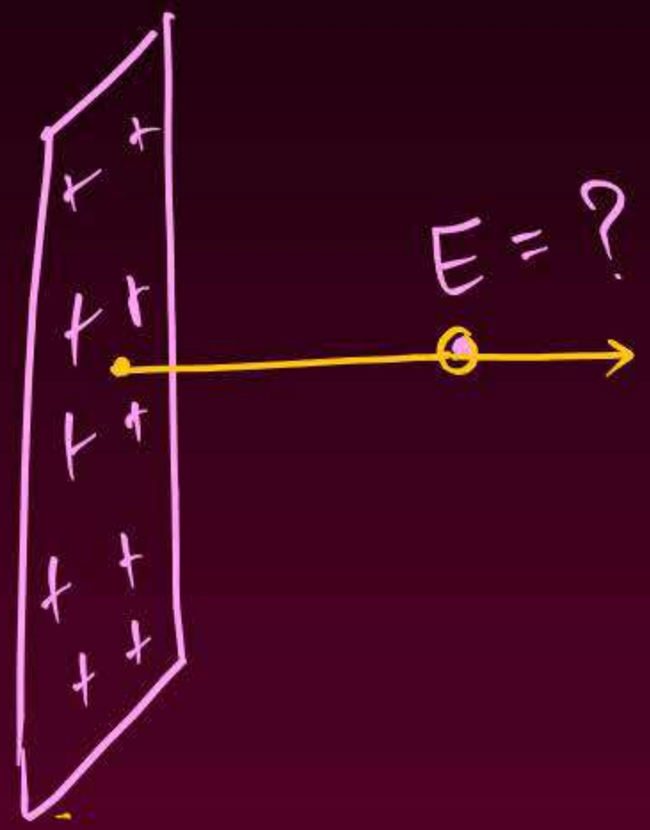
$$\boxed{E = \frac{\lambda}{2\pi r \varepsilon_0}} \; *$$

Formulae for Electric Field Strength Calculated From Gauss's Theorem

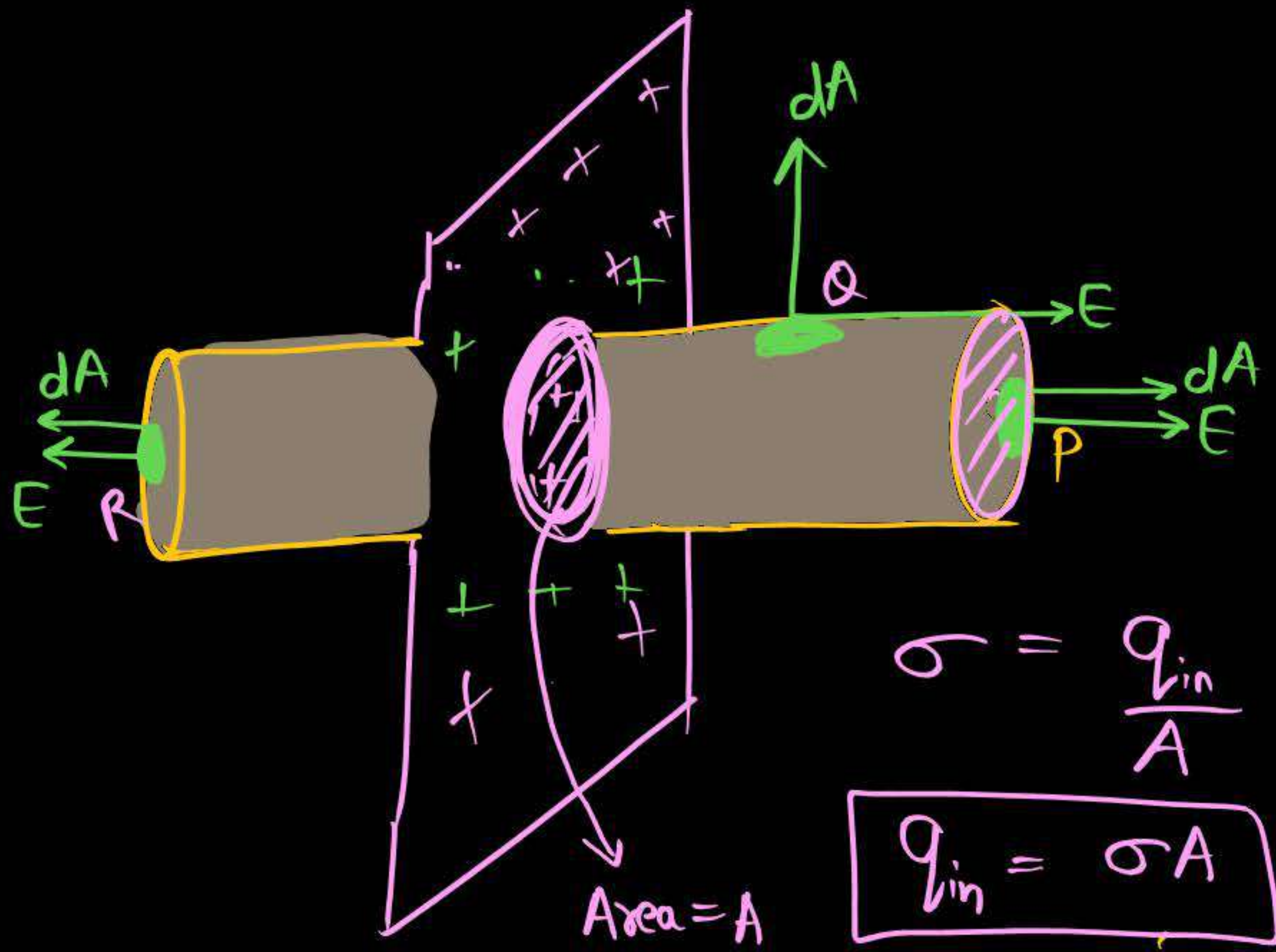
- Electric field strength due to an infinite plane sheet of charge per unit area σ is

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

independent of distance of point from the sheet.



To find Electric field at point P. Draw a cylindrical gaussian surface.



$$\sigma = \frac{q_{in}}{A}$$

$$\boxed{q_{in} = \sigma A}$$

Using Gauss Theorem

$$\oint_P E\,dA\cos 0^\circ + \int_Q E\,dA\cos 90^\circ + \int_R E\,dA\cos 0^\circ = \frac{q_{in}}{\varepsilon_0}$$

$$\int E\,dA + 0 + \int E\,dA = \frac{\sigma A}{\varepsilon_0}$$

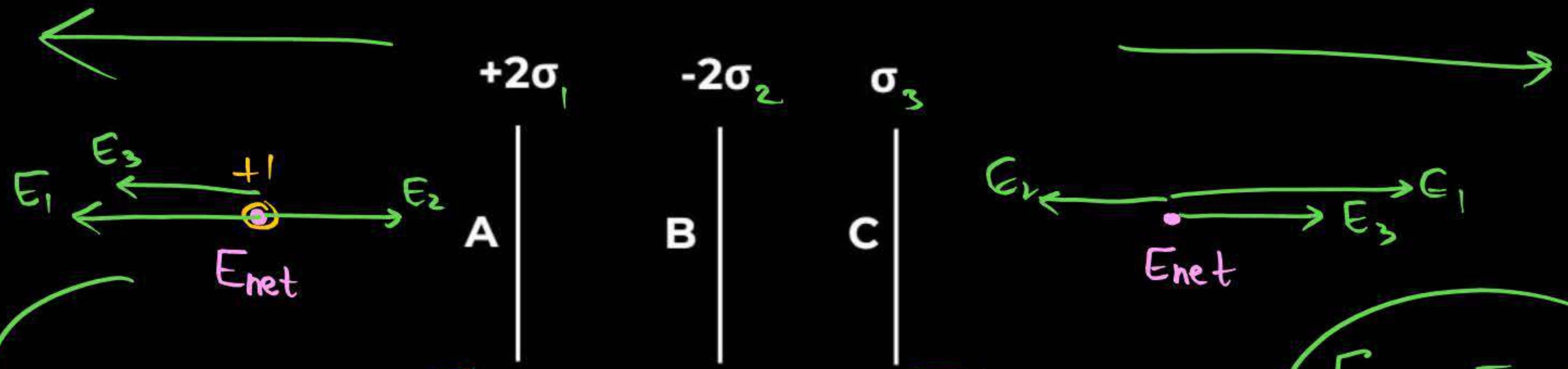
$$EA + EA = \frac{\sigma A}{\varepsilon_0}$$

$$2E\cancel{A} = \frac{\sigma \cancel{A}}{\varepsilon_0}$$

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

In the figure there are three infinite long thin sheets having surface charge density +2σ, −2σ and +σ respectively. Give the magnitude and direction of electric field at a point to the left of sheet of charge density +2σ and to the right of sheet of charge density +σ.

(2020-21)



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

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

$E_{net} = \frac{\sigma}{2\varepsilon_0}$

$$E_{net} = E_1 + E_3 - E_2$$
$$= \cancel{\frac{\sigma}{\varepsilon_0}} + \frac{\sigma}{2\varepsilon_0} - \cancel{\frac{\sigma}{\varepsilon_0}}$$
$$= \frac{\sigma}{2\varepsilon_0}$$

Formulae for Electric Field Strength Calculated From Gauss's Theorem

➤ Electric field strength due to a uniformly charged thin spherical shell or conducting sphere of radius R having total charge q, at a distance r from centre is

(i) at external point (For r > R)

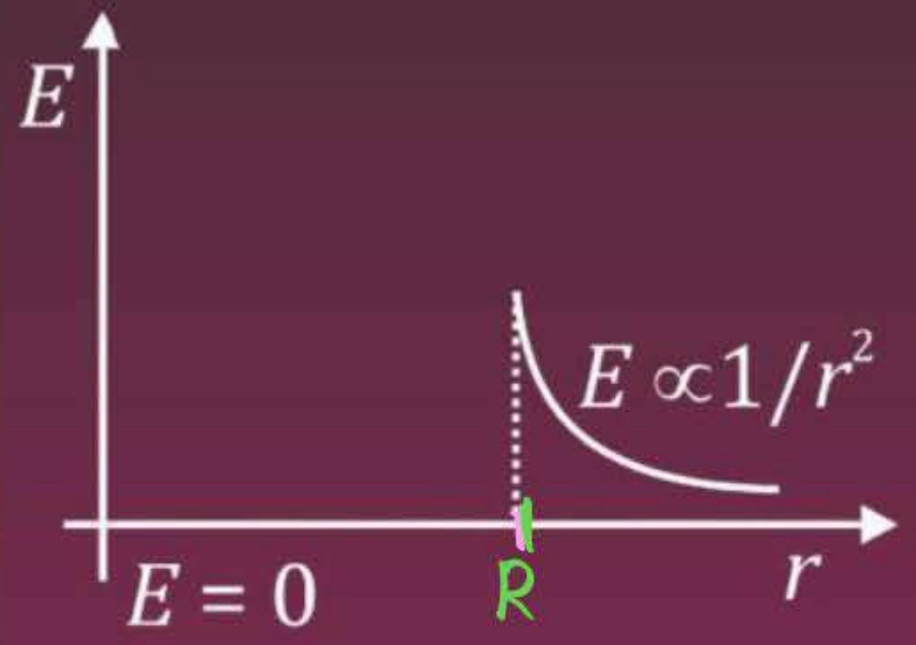
$$E_{ext} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

(ii) at surface point (For r = R)

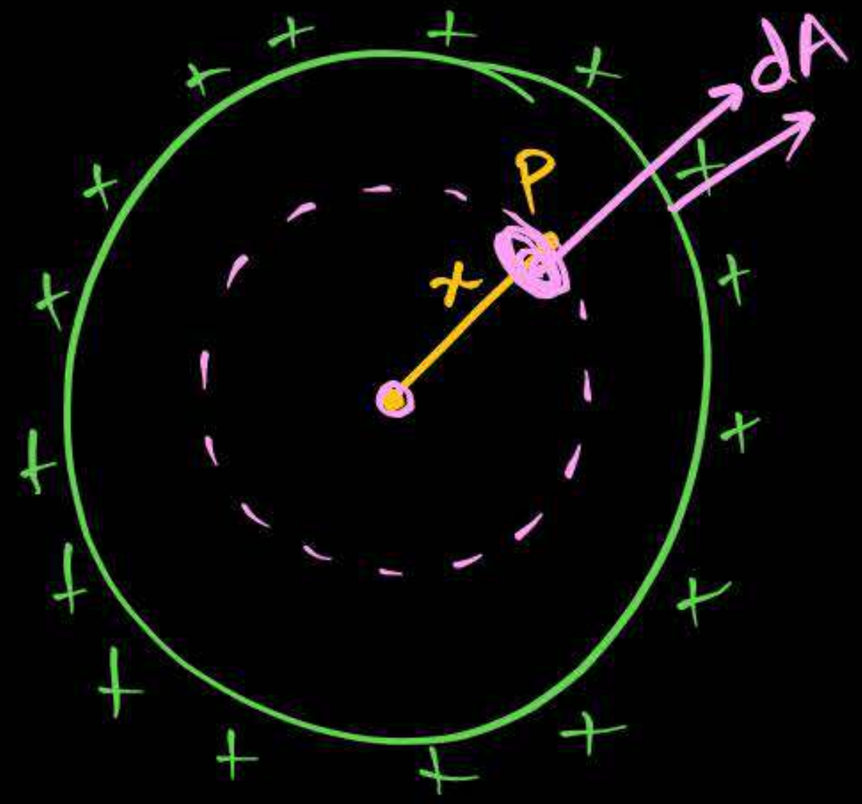
$$E_S = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^2}$$

(iii) at internal point (For r < R)

$$E_{int} = 0$$



To find Electric field inside shell



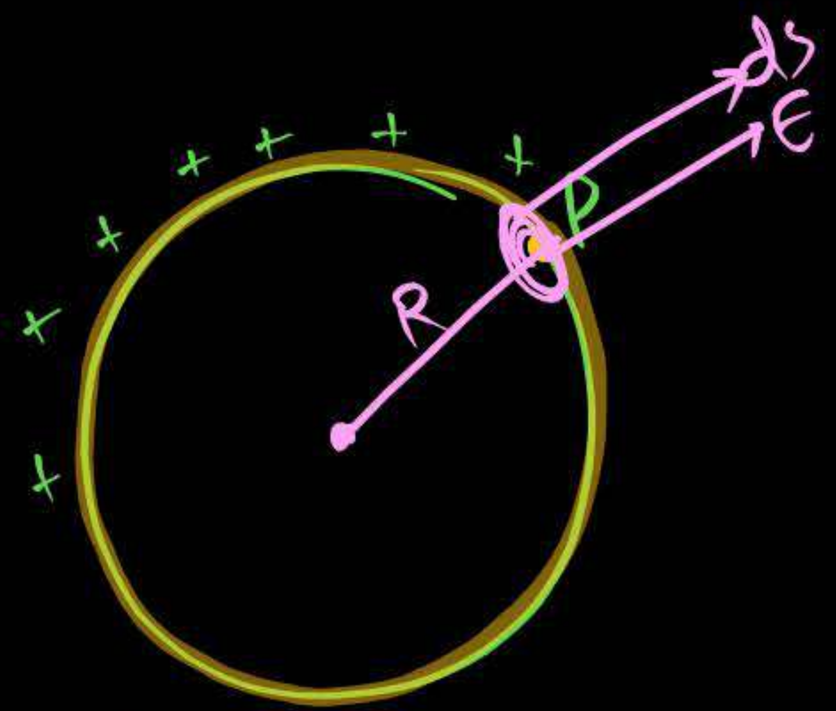
Draw a gaussian surface (spherical)

Using Gauss Theorem

$$\oint \vec{E}\cdot\vec{ds} = \frac{0}{\varepsilon_0} \quad \left\{ \text{enclosed charge} = 0 \right\}$$

$$E = 0$$

To find E.F at surface

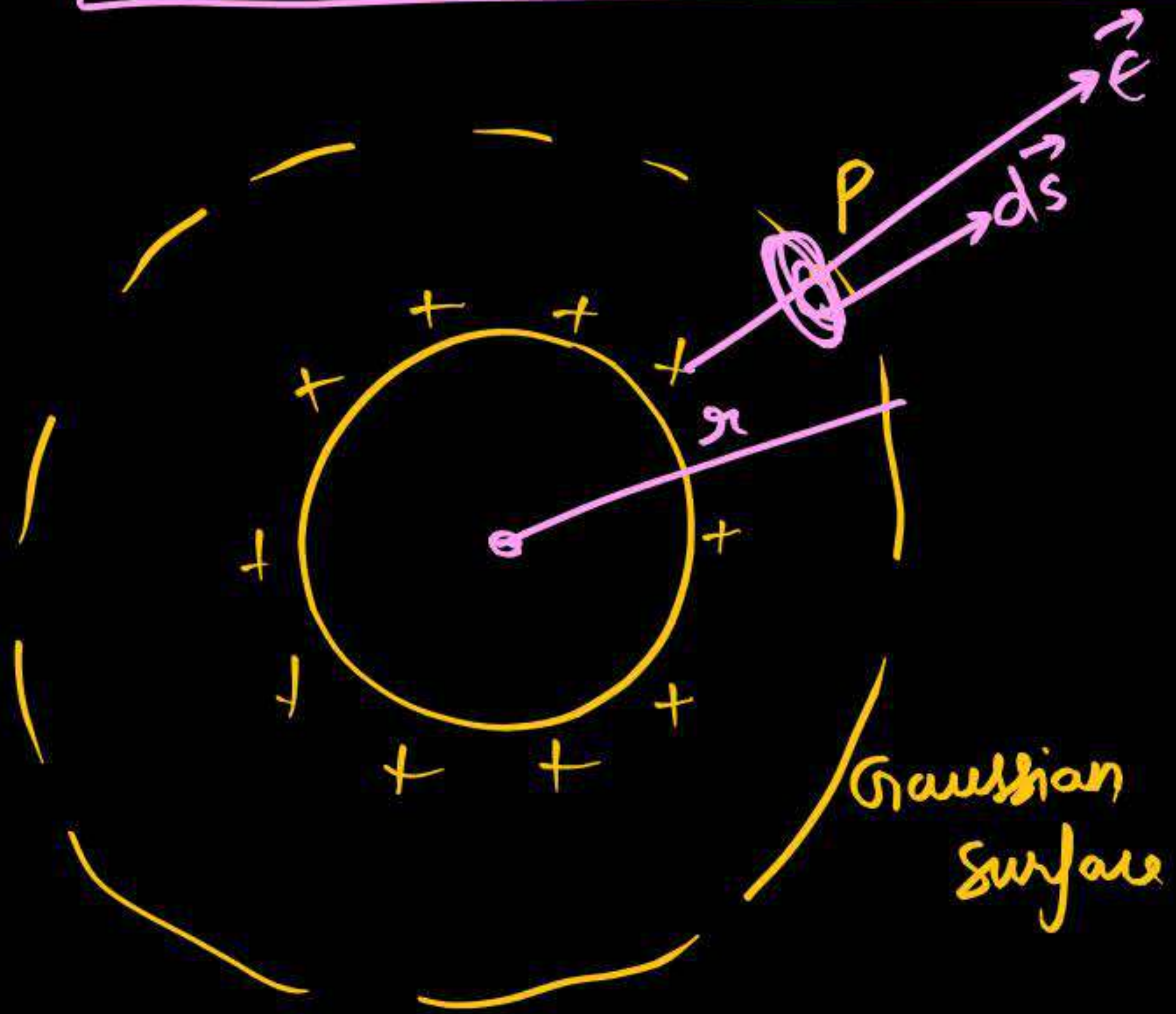


$$\oint E\,ds \cos 0^\circ = \frac{q_{in}}{\varepsilon_0}$$

$$E \int ds = \frac{Q}{\varepsilon_0}$$

$$E\, 4\pi R^2 = \frac{Q}{\varepsilon_0} \Rightarrow \boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R^2}}$$

To find E.F outside the shell



$$\oint E\,ds\cos 0^\circ = \frac{q_{in}}{\varepsilon_0}$$

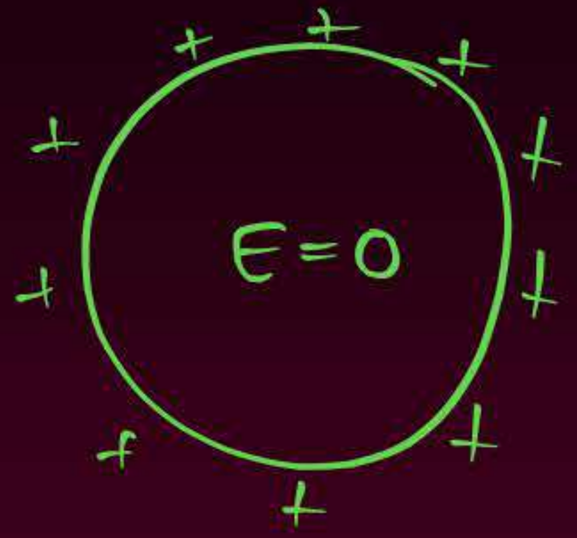
$$E\int ds = \frac{Q}{\varepsilon_0}$$

$$E\,4\pi r^2 = \frac{Q}{\varepsilon_0}$$

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

Electric Field due to a Conductor (Solid & Hollow)

1) Inside

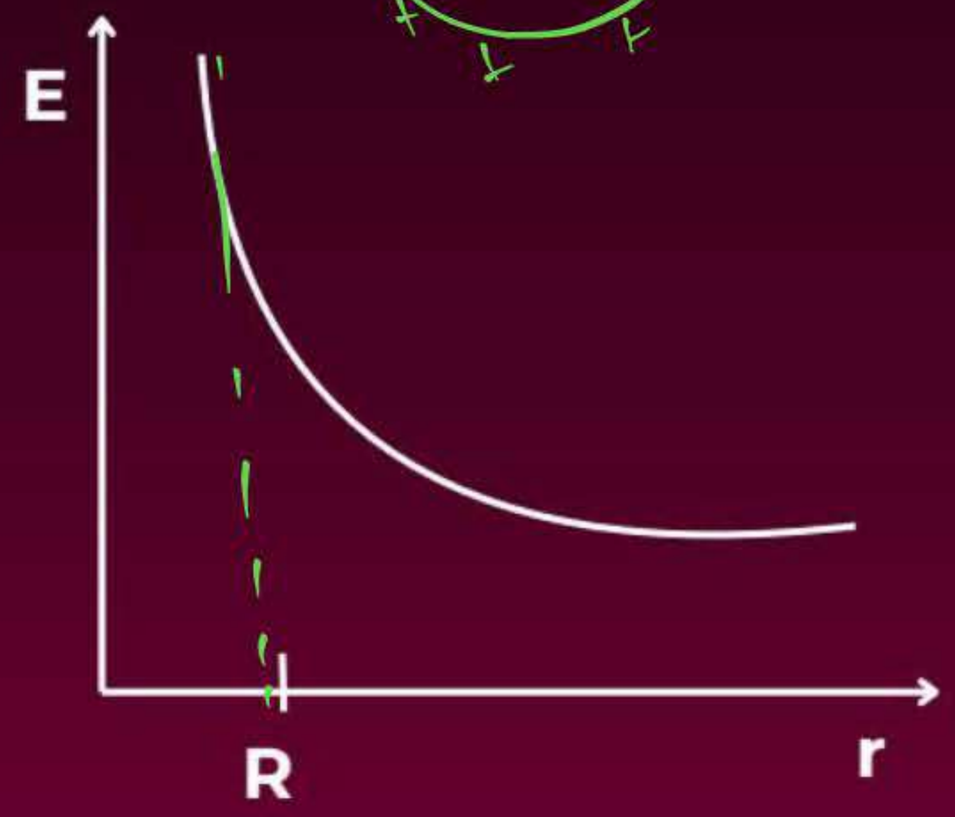


Surface

$E=\frac{kQ}{R^2}$

2) Outside

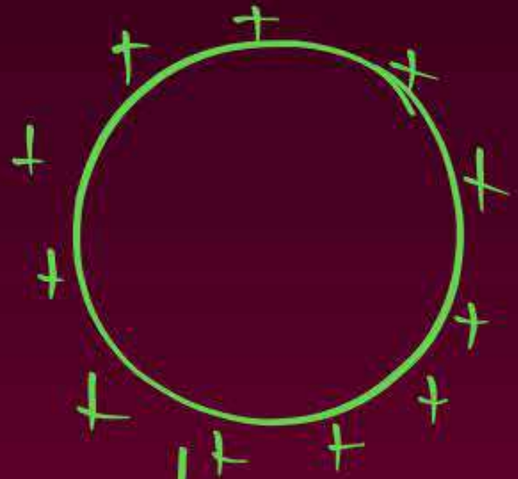
$E=\frac{kQ}{r^2}$



Electric Field due to Non-Conductor

Hollow

Same as conductor or shell

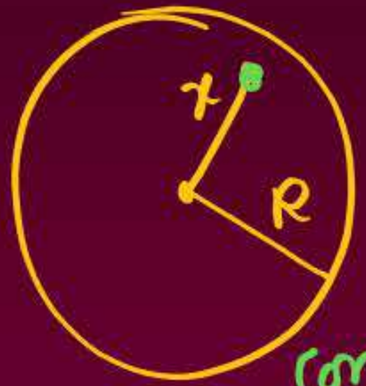


↓ like football

Solid

Inside

$$\frac{KQx}{R^3}$$



competitive exams

Surface

$$\frac{KQ}{R^2}$$

Outside

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

Same as conductor or shell

Two charges −q each are placed at the vertices A and B of an equilateral triangle ABC. If M is the mid-point of AB, the net electric field at C will point along

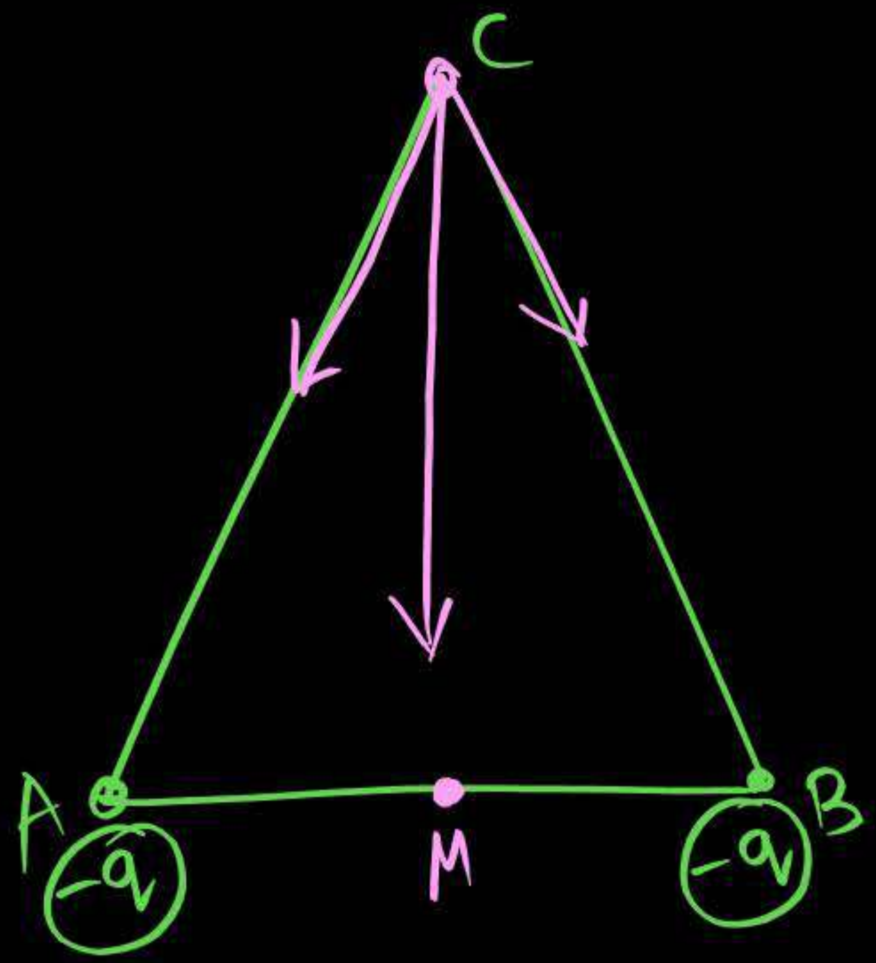
(CBSE 2025)

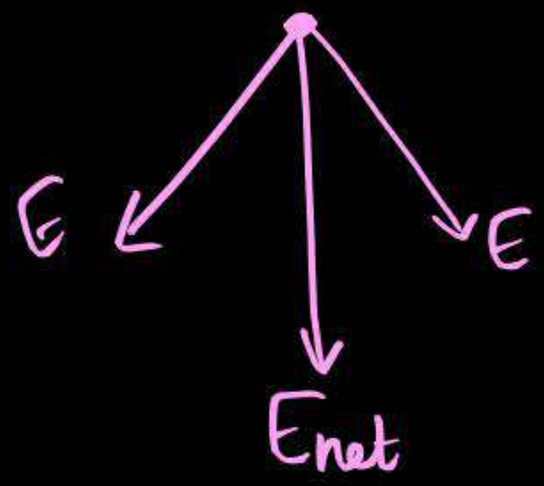
A CA

B CB

C MC

D CM ✓





Two identical point charges are placed at the two vertices A and B of an equilateral triangle of side l. The magnitude of the electric field at the third vertex P is E. If a hollow conducting sphere of radius $\frac{l}{4}$ is placed at P, the magnitude of the electric field at point P now becomes

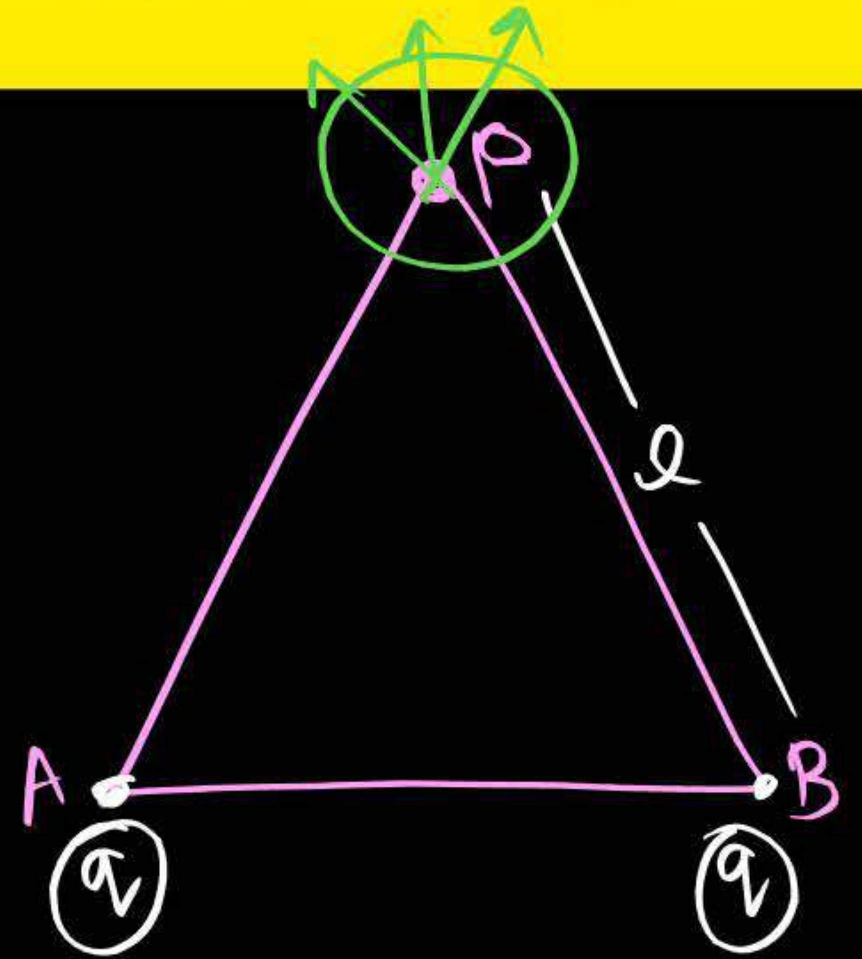
(CBSE 2025)

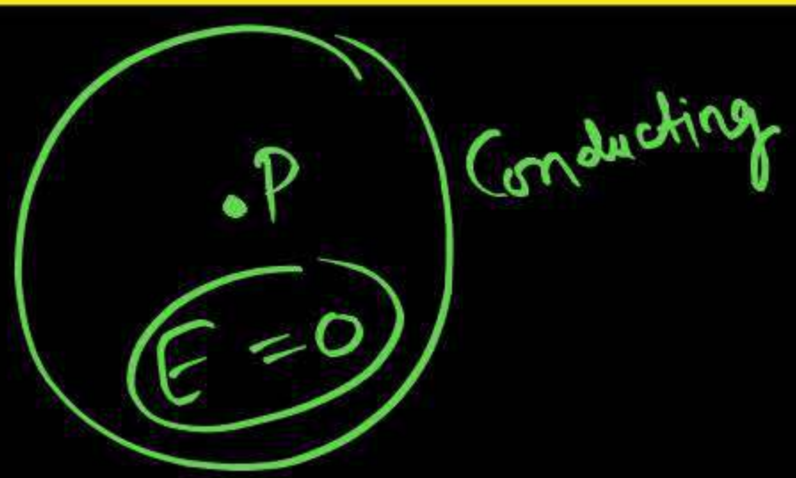
(A) $> E$

(B) E

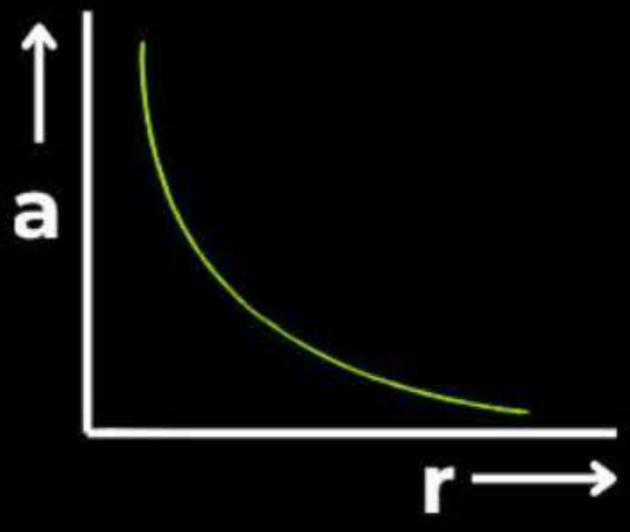
(C) $\frac{E}{2}$

(D) Zero





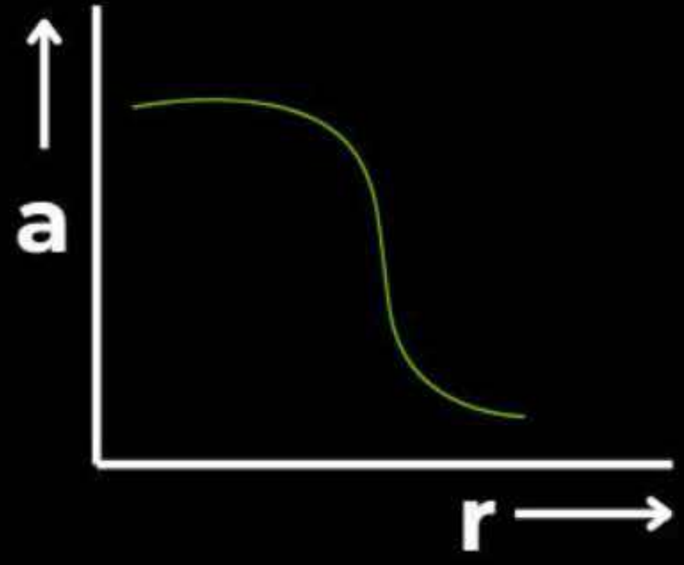
A charge Q is fixed in position. Another charge q is brought near charge Q and released from rest. Which of the following graphs is the correct representation of the acceleration of the charge q as a function of its distance r from charge Q? (CBSE 2025)

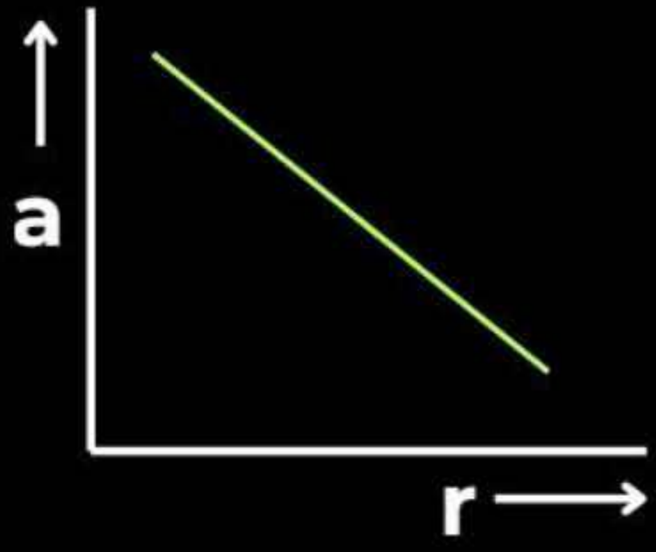
A


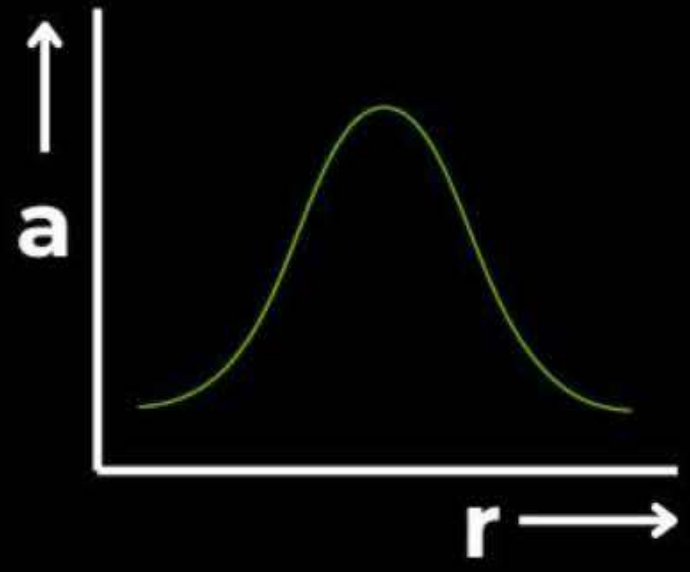
$a = \frac{qE}{m}$

$a = \frac{F}{m} = \frac{kQq}{mr^2}$

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

B


C


D


Two identical small conducting balls B_1 and B_2 are given $-7pC$ and $+4pC$ charges, respectively. They are brought in contact with a third identical ball B_3 and then separated. If the final charge on each ball is $-2pC$, the initial charge on B_3 was

(CBSE 2024)

A) -2pC

B) -3pC

C) -5pC

D) -15pC

B_1 $-7pC$ B_2 $+4pC$

Total charge $= -7+4$
$= -3pC$

B_1 $-2pC$ B_3 $-2pC$ B_2 $-2pC$

Total charge $= -2-2-2$
$= -6pC$

$-6pC$

$-7pC$ $+4pC$ $-3pC$

In an experiment, three microscopic latex spheres are sprayed into a chamber and became charged with charges +3e, +5e and −3e, respectively. All the three spheres came in contact simultaneously for a moment and got separated. Which one of the following are possible values for the final charge on the spheres? (CBSE 2022 Term-1)

A +5e, -4e, +5e = +6e ✗

B +6e, +6e, -7e = +5e ✓

C +4e, +3.5e, +5.5e = +13e ✗

D +5e, -8e, +7e = 4e ✗

+3e   +5e   −3e

Using conservation of charge

Total charge = +5e

Which one of the following statements is correct? Electric field due to static charges is

(CBSE 2025)

A. Conservative and field lines do not form closed loops.

B. Conservative and field lines form closed loops.

C. Non-conservative and field lines do not form closed loops.

D. Non-conservative and field lines form closed loops.

A small spherical shell S_1 has point charges $q_1=-3\,\mu C$, $q_2=-2\,\mu C$ and $q_3=9\,\mu C$ inside it. This shell is enclosed by another big spherical shell S_2. A point charge Q is placed in between the two surfaces S_1 and S_2. If the electric flux through the surface S_2 is four times the flux through surface S_1, find charge Q.

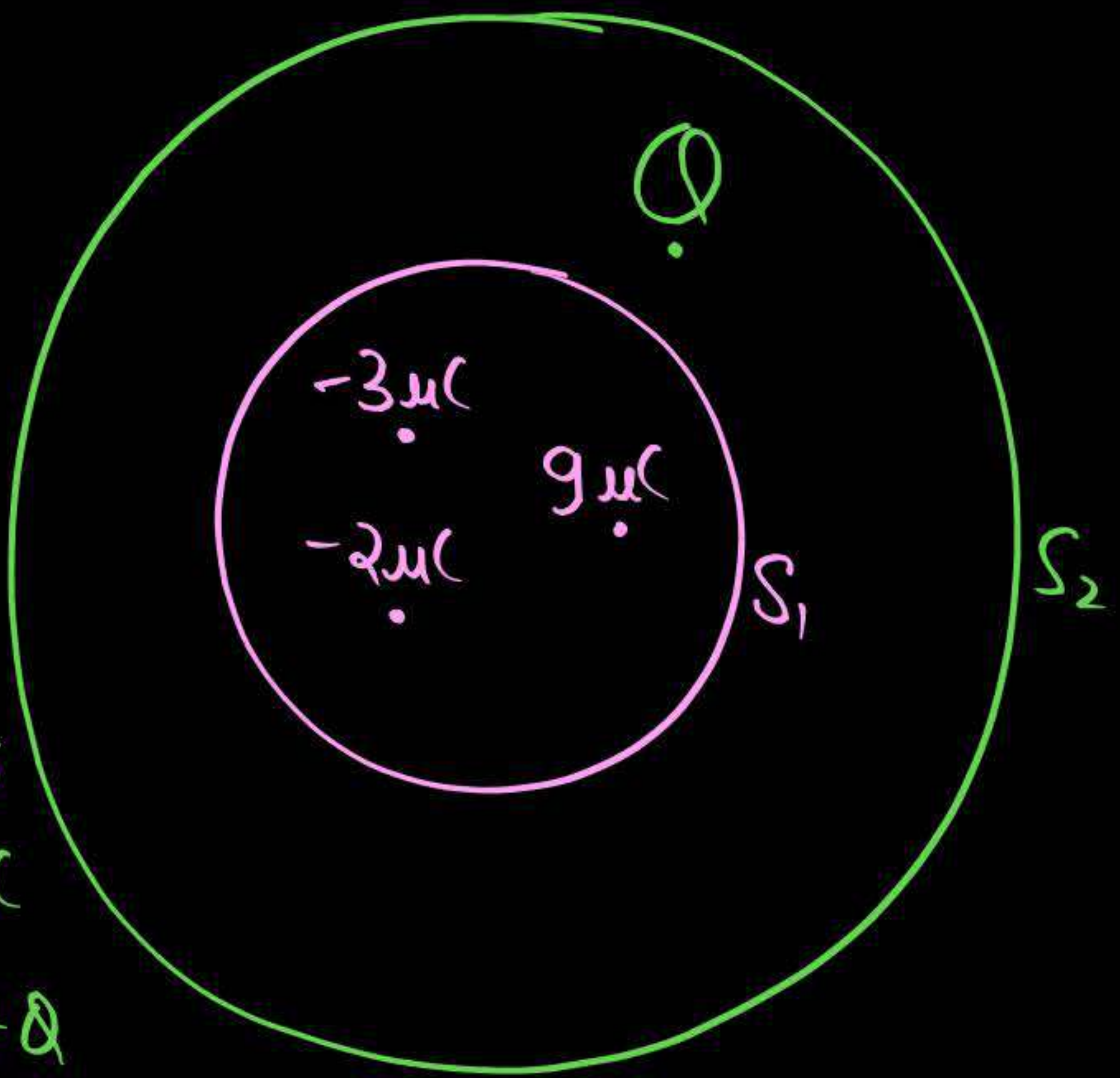
(5 Marks, CBSE 2025)

A) $6\mu C$

B) $12\mu C$

C) $18\mu C$

D) None



$q_{in}(S_1) = 9-5$
$= 4\mu C$

$q_{in}(S_2) = 4+Q$

$\phi_{S_2} = 4\times\phi_{S_1} \Rightarrow$ Given

$\phi_{S_1} = \dfrac{4}{\varepsilon_0}$ —— (1)

$\phi_{S_2} = \dfrac{4+Q}{\varepsilon_0}$ —— (2)

$\phi_{S_2} = 4\phi_{S_1}$

$\dfrac{4+Q}{\cancel{\varepsilon_0}} = 4\left(\dfrac{4}{\cancel{\varepsilon_0}}\right)$

$4+Q = 16$

$Q = 16-4$

$= 12\mu C$

Two point charges of +1 μC and +4 μC are kept 30 cm apart. How far from the +1 μC charge, on the line joining the two charges, will the net electric field be zero?

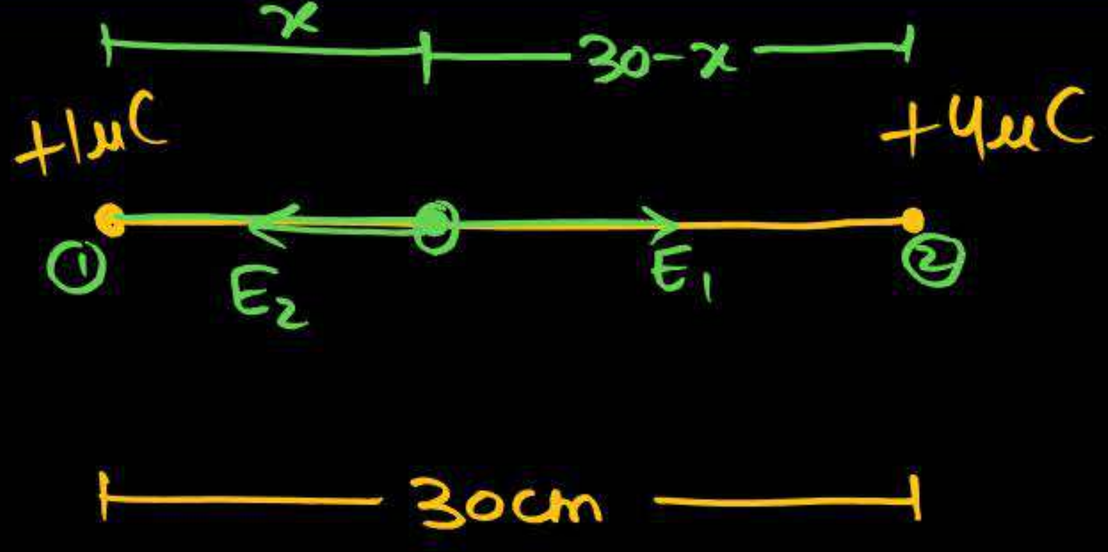
(5 Marks, CBSE 2020)

A) 10 cm ✓

B) 0.1 cm

C) 18 cm

D) None



$$E_1 = E_2$$

$$\frac{\cancel{K}(1)}{x^2} = \frac{\cancel{K}(4)}{(30-x)^2}$$

$$(30-x)^2 = 4x^2$$

$$(30-x)^2 = (2x)^2$$

$$30 - x = 2x$$

$$30 = 2x + x$$

$$30 = 3x$$

$$x = 10\text{ cm}$$

A particle of charge 2 μC and mass 1.6 g is moving with a velocity $4\hat{i}\ ms^{-1}$. At t=0, the particle enters in a region having an electric field $\vec{E}\ (NC^{-1}) = (80\hat{i} + 60\hat{j})$. Find the velocity of the particle at t=5s.

(3 Marks, CBSE 2020)

A) $4\hat{i} + 1.6\hat{j}$

B) $4.5\hat{i} + 0.375\hat{j}$

C) $3.2\hat{i} - 1.252\hat{j}$

D) $1.1\hat{i} + 0.225\hat{j}$

$q = 2\mu C = 2\times10^{-6}\,C$

$m = 1.6g = 1.6\times10^{-3}\,kg$

$\vec{u} = 4\hat{i}$

$\vec{E} = 80\hat{i} + 60\hat{j}$

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

$= 2\times10^{-6}(80\hat{i} + 60\hat{j})$

$\vec{F} = 1.6\times10^{-4}\hat{i} + 1.2\times10^{-4}\hat{j}$

$\vec{a} = \frac{\vec{F}}{m} = \frac{1.6\times10^{-4}}{1.6\times10^{-3}}\hat{i} + \frac{1.2\times10^{-4}}{1.6\times10^{-3}}\hat{j}$

$\boxed{\vec{a} = 0.1\hat{i} + 0.075\hat{j}}$

$\vec{v} = \vec{u} + \vec{a}t$

$\vec{v} = 4\hat{i} + (0.1\hat{i} + 0.075\hat{j})5$

$= 4\hat{i} + 0.5\hat{i} + 0.375\hat{j}$

$= 4.5\hat{i} + 0.375\hat{j}$

The following propositions COULD be true for a Gaussian surface across which there is no net flux.

(P)The Gaussian surface contains no charges

(Q)There is no net charge inside the surface

(R)On the surface, there is no electric field at all

(S)The quantity of field lines entering and leaving the surface is the same

Which of the following claims is/are ABSOLUTELY true?

A. Only the statement (Q)

B. Both statements (P) and (S)

C. Both statements (Q) and (R)

D. Both statements (Q) and (S)

Electric field lines are pictorial representations of electric field due to static charges on the plane of a paper.

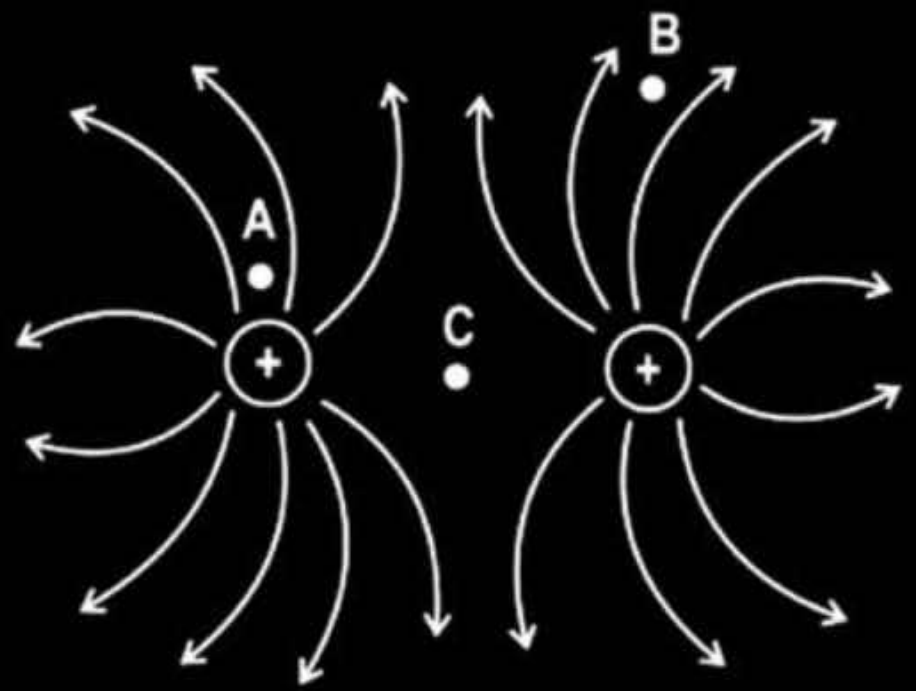
Study the given electric field representation and identify one INCORRECT qualitative impression given by this representation.

A. The electric field at point A is stronger than at Point B

B. The electric field distribution is two-dimensional

C. The electric field at point C is zero

D. The electric field always points away from a positive charge



C_1 and C_2 are two hollow cubes with a same vertex enclosing charge 4Q and 6Q respectively as shown in figure. The ratio of electric flux passing through C_1 and C_2 is

A 1/5

B 4/5

C 2/5 ✓

D 1/2

for C_1

$$\phi = \frac{4Q}{\varepsilon_0} \times \frac{1}{4}$$

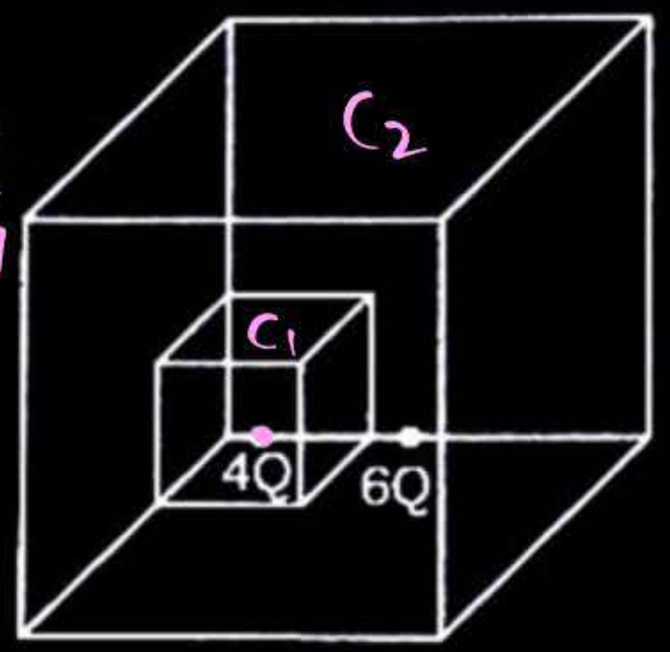
$$\phi_{C_1} = \frac{Q}{\varepsilon_0}$$

for C_2

$$\phi = \frac{4Q+6Q}{\varepsilon_0} \times \frac{1}{4}$$

$$= \frac{5\cancel{10}Q}{\varepsilon_0} \times \frac{1}{\cancel{4}2}$$

$$\phi_{C_2} = \frac{5Q}{2\varepsilon_0}$$



$$\frac{\phi_{C_1}}{\phi_{C_2}} = \frac{\frac{\cancel{Q}}{\cancel{\varepsilon_0}}}{\frac{5\cancel{Q}}{2\cancel{\varepsilon_0}}} = \frac{2}{5}$$

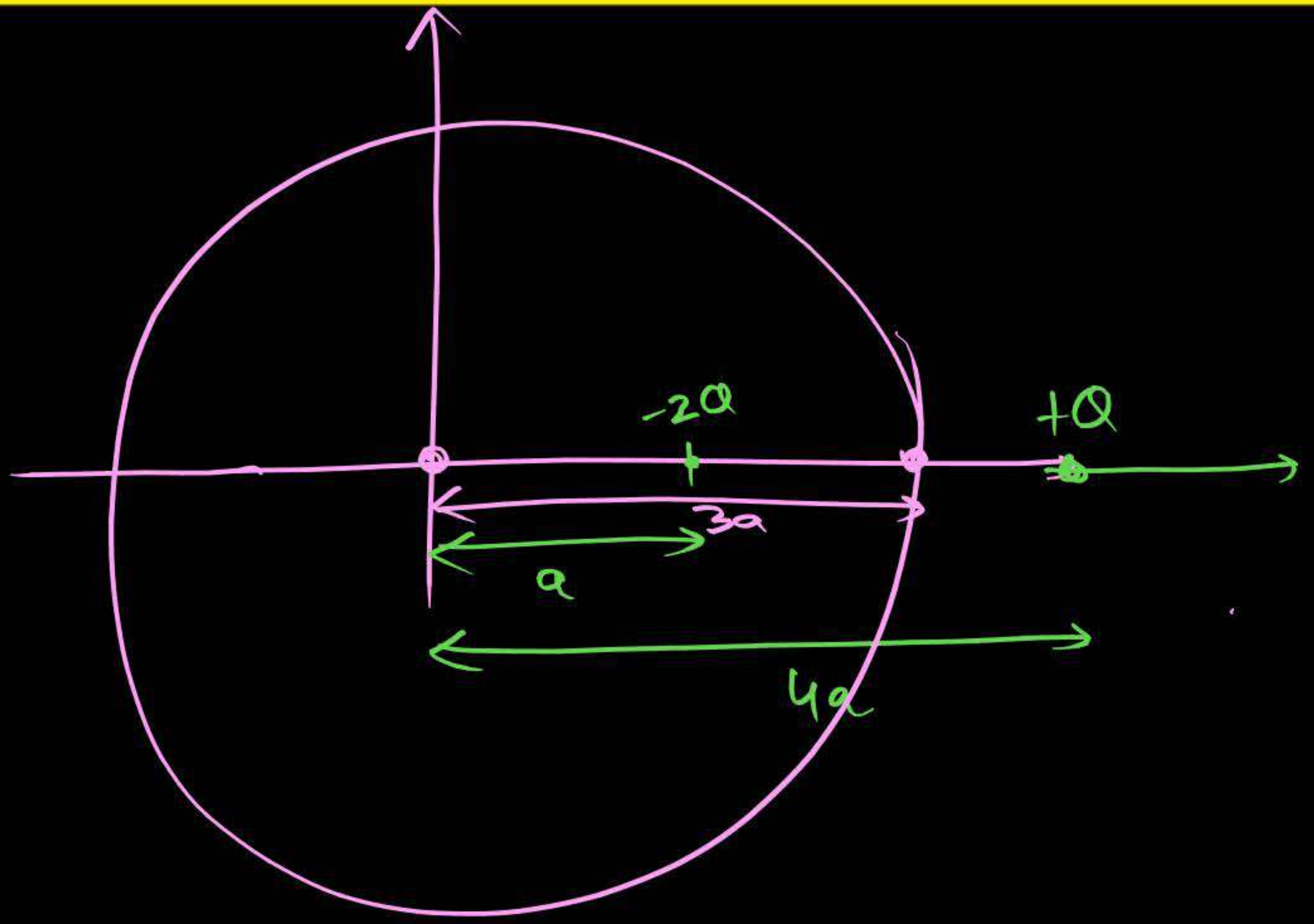
Two charges of magnitude –2Q and +Q are located at points (a, 0) are (4a, 0) respectively. What is the electric flux due to these charges through a sphere of radius '3a' with its centre at origin?

A $\frac{2Q}{\varepsilon_0}$

B $\frac{-2Q}{\varepsilon_0}$ ✓

C $\frac{3Q}{\varepsilon_0}$

D $\frac{-3Q}{\varepsilon_0}$



$\phi = \frac{-2Q}{\varepsilon_0}$

An electric dipole placed in an electric field of intensity 2×10^5 N/C at an angle of 30° experiences a torque equal to 4 Nm. The charge on the dipole of dipole length 2 cm is:

A $7\mu C$

B 8 mC

C 2 mC ✓

D 5 mC

$E = 2 \times 10^5$ N/C

$\theta = 30°$

$\tau = 4$ Nm

$l = 2$ cm $= 2 \times 10^{-2}$ m

$q = ?$

$\tau = pE\sin\theta$

$\tau = q\,(\text{separation})\,E\,\sin 30°$

$2\cancel{4} = q \times \cancel{2} \times 10^{-2} \times \cancel{2} \times 10^{5} \times \frac{1}{\cancel{2}}$

$2 = q \times 10^{3}$

$2 \times 10^{-3} = q$

$\boxed{q = 2\,mC}$

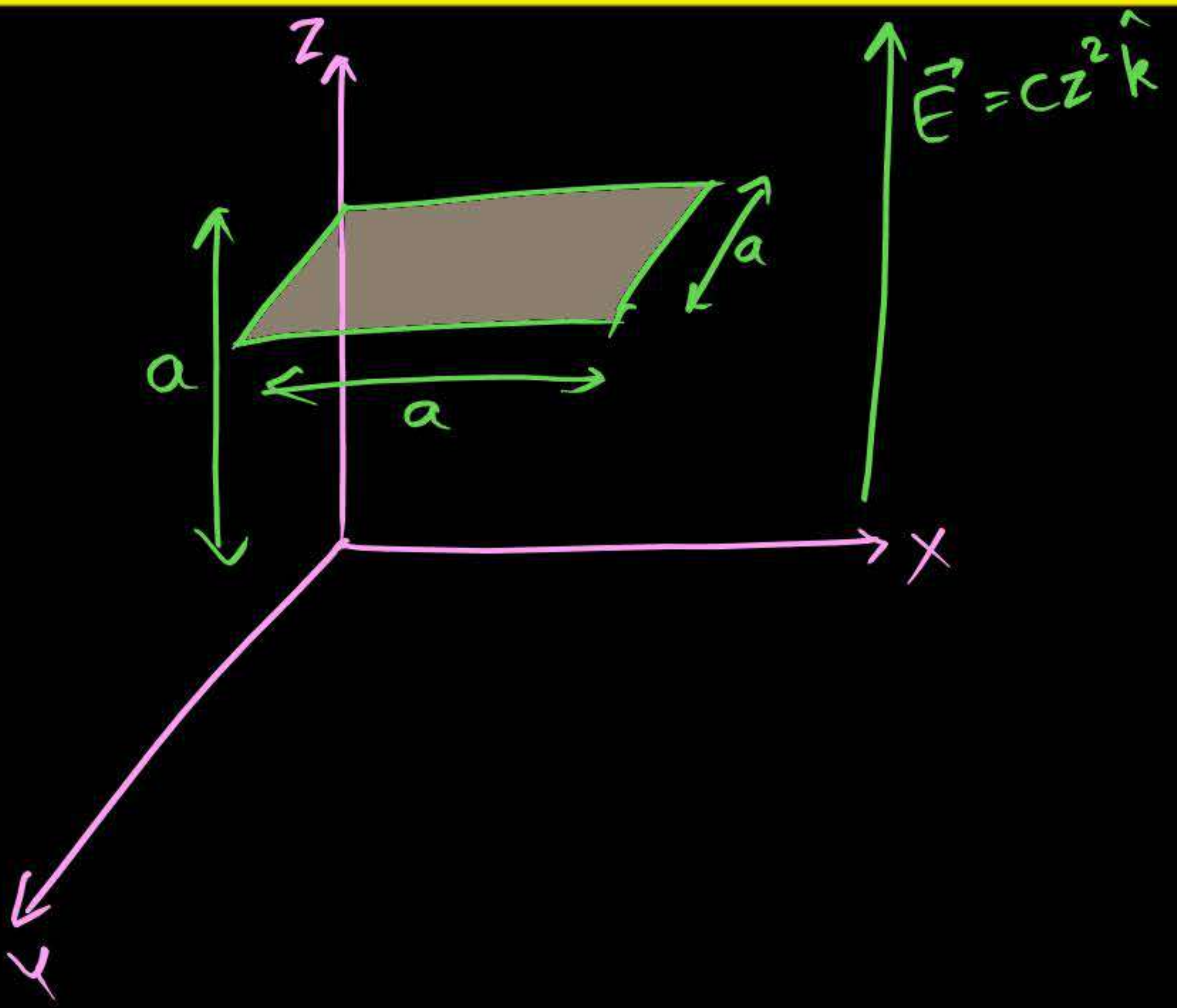
A square sheet of side 'a' is lying parallel to XY-plane at z = a. The electric field in the region is $\vec{E} = cz^2\hat{k}$. The electric flux through the sheet is:

A a^4c

B $\frac{1}{8}a^3c$

C $\frac{1}{3}a^4c$

D θ



$$\phi = \vec{E} \cdot \vec{A}$$
$$= cz^2\hat{k} \cdot (aa)\hat{k}$$
$$= ca^2\hat{k} \cdot a^2\hat{k}$$
$$= ca^4$$

$\hat{k} \cdot \hat{k} = 1$

Assertion (A) : A negative charge in an electric field moves along the direction of the electric field.

Reason (R) : On a negative charge a force acts in the direction of the electric field.

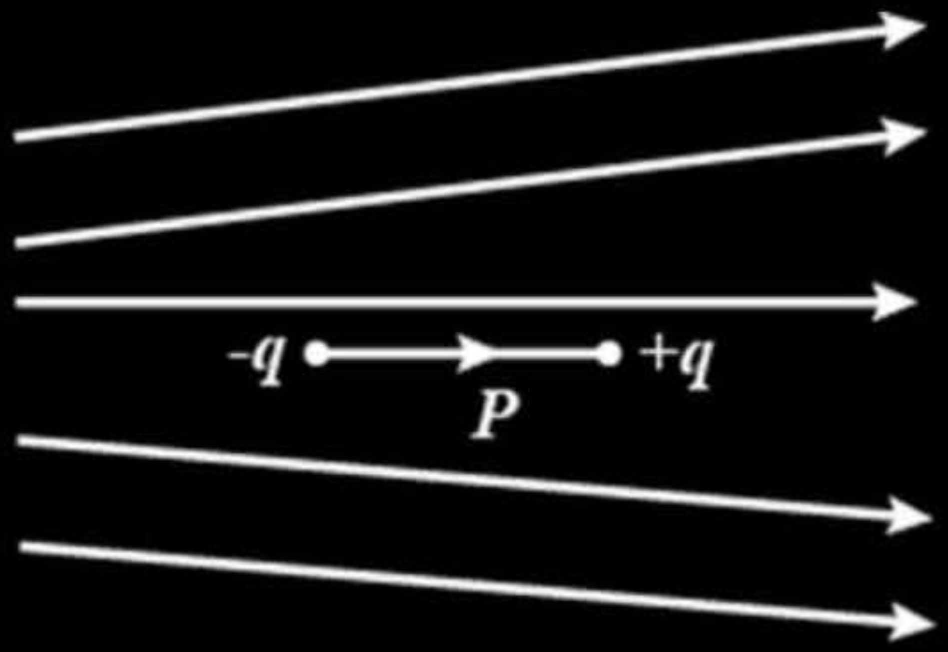
A. If both (A) and (R) are true and (R) is correct explanation of (A).

B. If both (A) and (R) are true but (R) is not the correct explanation of (A).

C. If (A) is true but (R) is false.

D. If both (A) and (R) are false.

The given figure shows electric field lines in which an electric dipole p is placed as shown. Which of the following statements is correct?



A The dipole will not experience any force

B The dipole will experience a force towards right

C The dipole will experience a force towards left

D The dipole will experience a force upwards

The necessary condition for the ratio of electric field intensity due to an electric dipole of dipole length 2a at its axial point to the equatorial point to be 2 : 1 is :

A. $r >> a$, where r is the distance from the midpoint of the dipole to the concerned point

B. $r << a$, where r is the distance from the midpoint of the dipole to the concerned point

C. $r = a$, where r is the distance from the midpoint of the dipole to the concerned point

D. none of the above

Four objects W, X, Y and Z, each with charge +q are held fixed at four points of a square of side d as shown in the figure. Objects X and Z are on the midpoints of the sides of the square. The electrostatic force exerted by object W on object X is F. Then the magnitude of the force exerted by object W on Z is

A. F/7

B. F/5

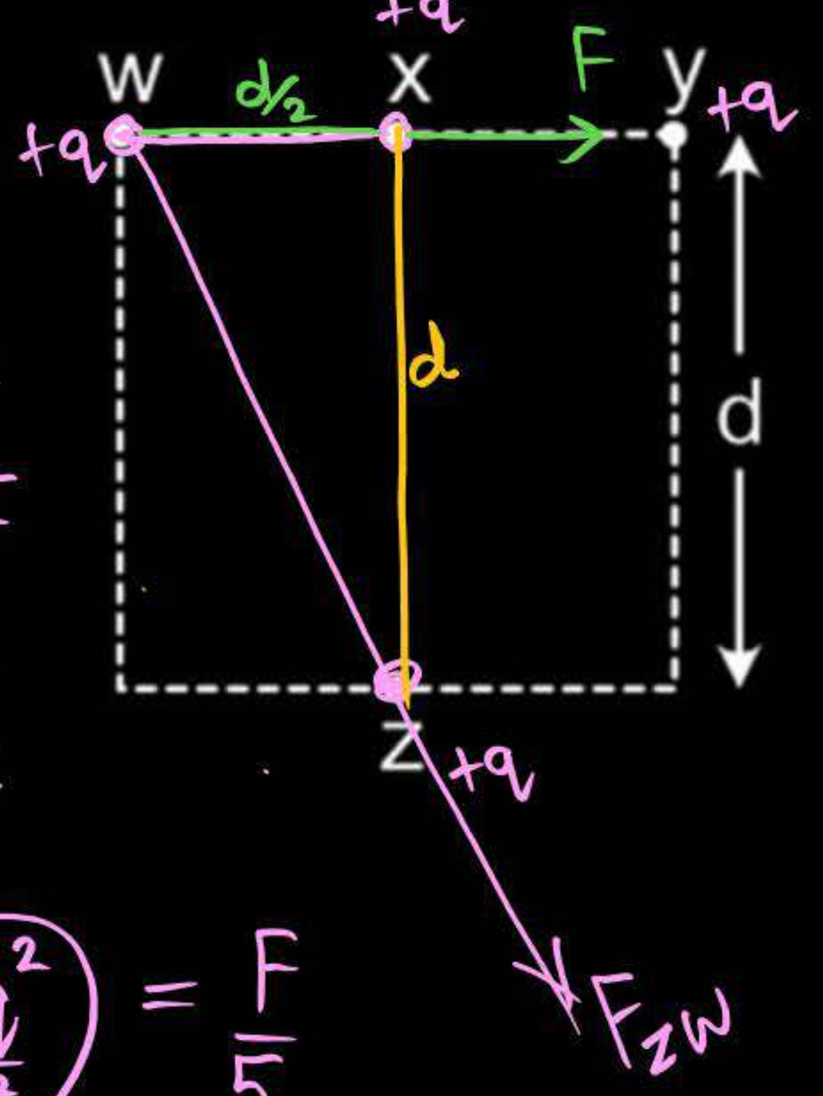
C. F/3

D. F/2

$$F_{xw} = \frac{kq^2}{(d/2)^2} = 4\frac{kq^2}{d^2} \quad \text{— (1)}$$

$$WZ^2 = d^2 + \left(\frac{d}{2}\right)^2$$
$$= d^2 + \frac{d^2}{4}$$
$$= \frac{4d^2 + d^2}{4}$$
$$WZ^2 = \frac{5d^2}{4}$$

$$F_{zw} = \frac{kq^2}{WZ^2}$$
$$= \frac{kq^2}{\frac{5d^2}{4}}$$
$$= \frac{4}{5}\frac{kq^2}{d^2} = \frac{F}{5}$$



Two point charges q_1 and q_2, of magnitude $+10^{-8}$ C and -10^{-8} C, respectively, are placed 0.1 m apart. Calculate the electric fields at points A, B shown in figure.

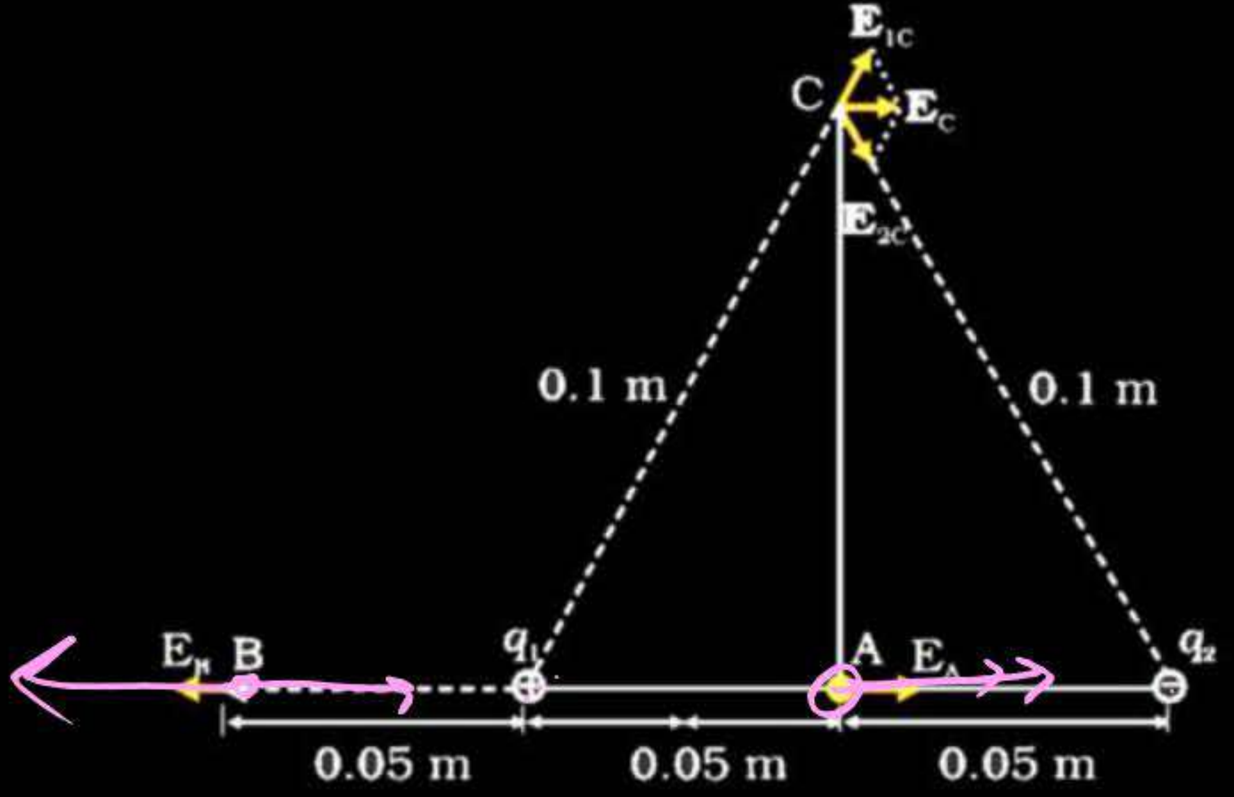
$E_A = ?$

A) 2.7×10^5 N/C

B) 7.2×10^4 N/C

C) 3.6×10^2 N/C

D) None



$E_{net} = E_+ - E_-$

(B)

$E_A = E_1 + E_2$

A particle whose mass 5×10^{-6} g is held over a huge horizontal charge sheet with a density of 4×10^{-6} C/m^2. What charge should be given to this particle such that it does not fall when released?

A) 1.1×10^{-11}

B) 5.5×10^{-12}

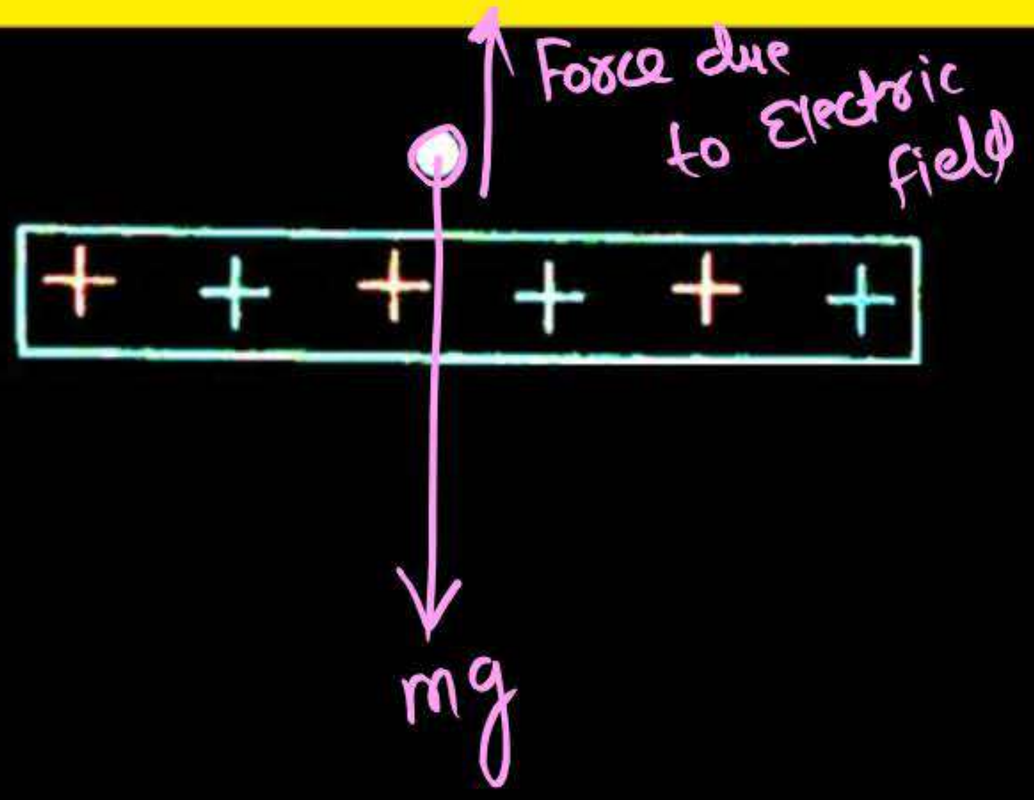
C) 2.2×10^{-13}

D) 0.1×10^{-18}

$$F_e = mg$$

$$qE = mg$$

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



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

$$m = 5 \times 10^{-6}\ \text{gm}$$
$$= 5 \times 10^{-9}\ \text{gm}$$

$$q = \frac{5 \times 10^{-9} \times 10 \times 2\varepsilon_0}{\sigma}$$

$$q = \frac{5 \times 10^{-9} \times 10 \times 2 \times 8.85 \times 10^{-12}}{4 \times 10^{-6}} = 2.2 \times 10^{-13}\ \text{C}$$

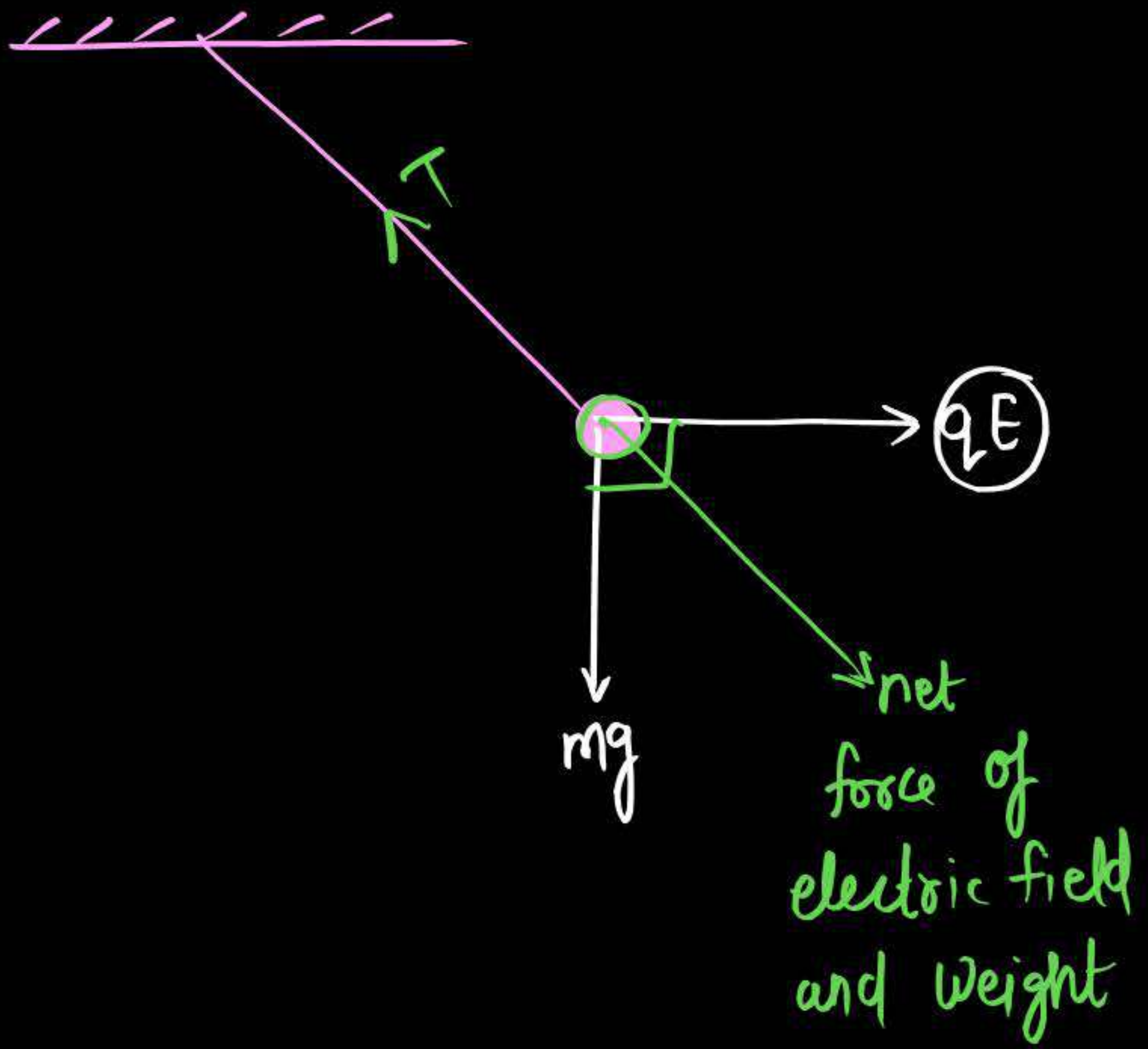
A pendulum bob of mass 30.7×10^{-6} kg and carrying a charge 2×10^{-8} C is at rest in a horizontal uniform electric field of 20000 V/m. The tension in the thread of the pendulum is ($g = 9.8\ m/s^2$)

A. 3×10^{-4} N

B. 4×10^{-4} N

C. 5×10^{-4} N ✓

D. 6×10^{-4} N



$F = qE$ (due to electric field)

$T = F_{net}$ (Electric + mg)

$T = \sqrt{(qE)^2 + (mg)^2}$

$T = \sqrt{q^2E^2 + m^2g^2}$

$T = 5 \times 10^{-4}$ N

(A) Using Gauss's law, show that the electric field $\vec{E}$ at a point due to a uniformly charged infinite plane sheet is given by $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$ where symbols have their usual meanings.

(B) Electric field $\vec{E}$ in a region is given by $\vec{E} = (5x^2 + 2)\,\hat{i}$, where E is in N/C and x is in meters. A cube of side 10 cm is placed in the region as shown in figure.

Calculate the electric field through left right faces of the cube.

A) 2×10^{-3}

B) 5×10^{-4} ✓

C) 9×10^{-2}

D) 13×10^{-6}

$\vec{E} = (5x^2+2)\,\hat{i}$

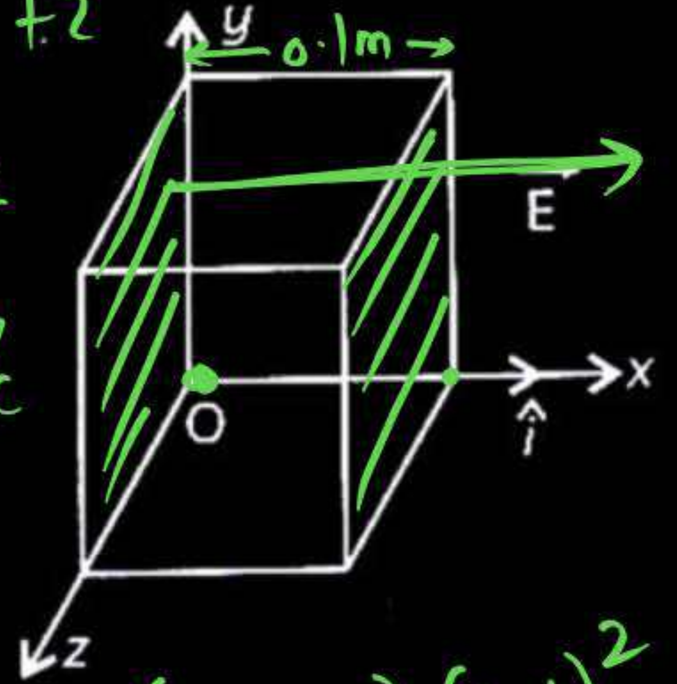
$= 5(0)^2 + 2$

$\boxed{E_1 = 2\ N/C}$

$E = 5(0.1)^2 + 2$

$= 0.5 + 2$

$E_2 = 2.05\ N/C$



$\phi_{net} = (E_2 - E_1)A = (2.05 - 2)(0.1)^2$

$= 0.05\times0.01 = 5\times10^{-4}\ N/C$

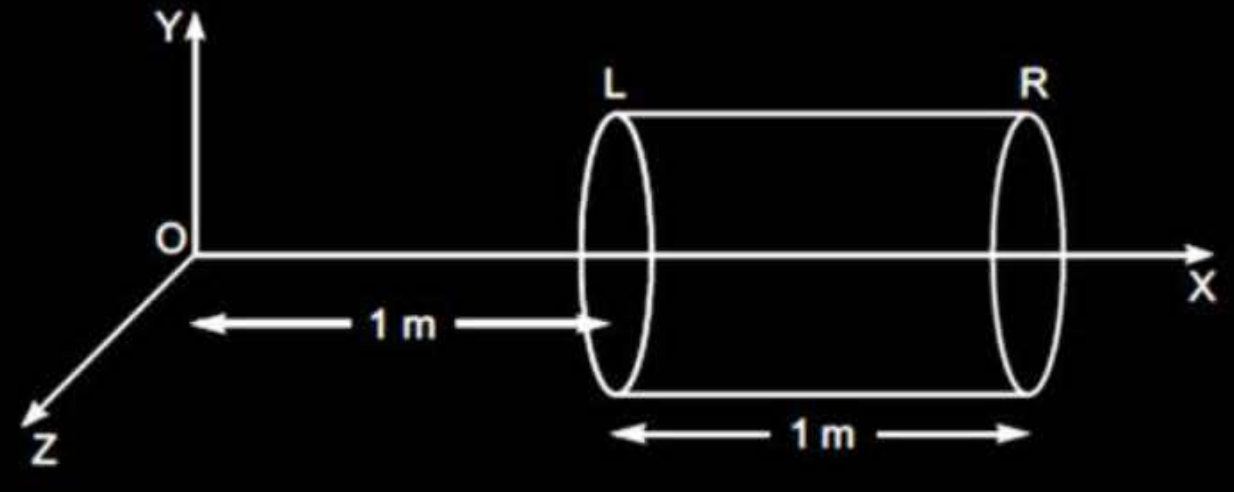
A hollow cylindrical box of length 1 m and area of cross-section 25 cm^2 is placed in a three dimensional coordinate system as shown in the figure. The electric field in the region is given by $\vec{E} = 50x\hat{i}$, where E is in NC^{-1} and x is in metres. Find net flux through the cylinder.

A) $0.125\ Nm^2/C$

B) $2.250\ Nm^2/C$

C) $3.105\ Nm^2/C$

D) $10.2\ Nm^2/C$



According to Coulomb's law, which is the correct relation for the following figure?

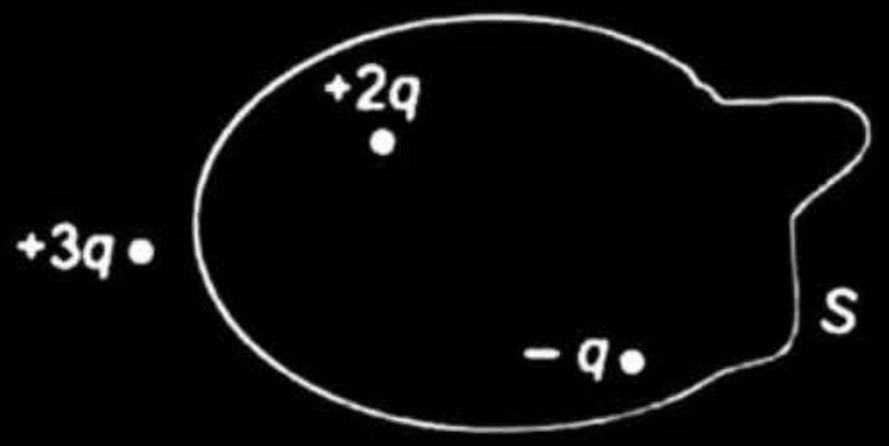
A $q_1q_2 > 0$

B $q_1q_2 < 0$

C $q_1q_2 = 0$

D $1 > q_1 / q_2 > 0$

Figure shows three point charges $+2q$, $-q$ and $+3q$. The charges $+2q$ and $-q$ are enclosed within a surface 'S'. What is the electric flux due to this configuration through the surface 'S'?



The sum of two point charges is $7 \mu C$. They repel each other with a force of 1 N when kept 30 cm apart in free space. Calculate the value of each charge.

H.W

A small conducting sphere of radius 'r' carrying a charge +q is surrounded by a large concentric conducting shell of radius R on which a charge +Q is placed. Using Gauss's law derive the expressions for the electric field at a point 'x'.

(i) Between the sphere and the shell ($r < x < R$).

(ii) Outside the spherical shell.

H.W

Two identical conducting balls A and B have charges –Q and +3Q respectively. They are brought in contact with each other and then separated by a distance d apart. Find the nature of Coulomb force between them.

A) Attractive

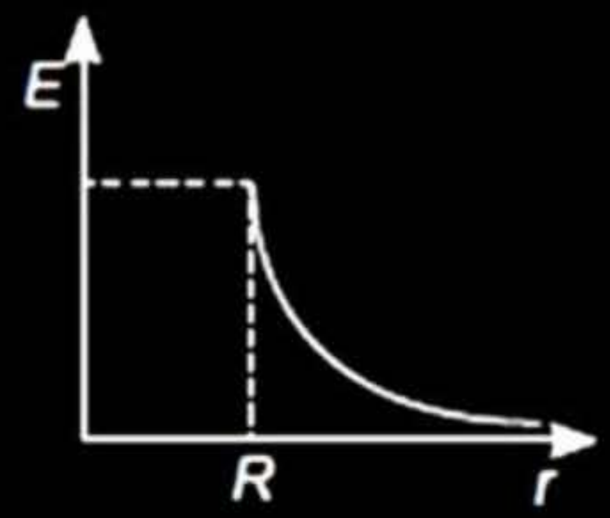
B) Repulsive

C) Neutral

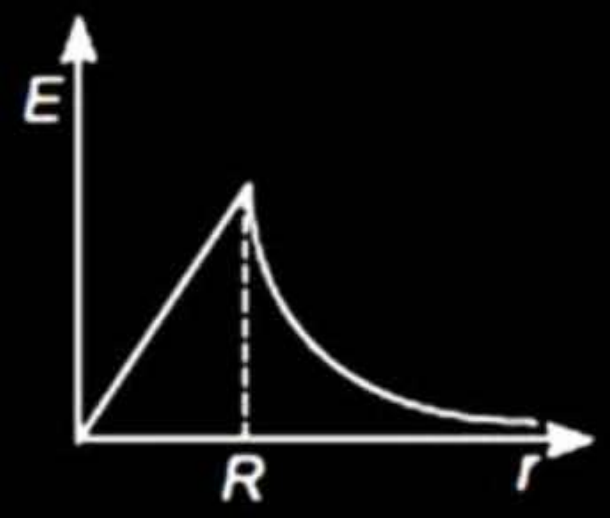
D) Thulle

Which of the following graphs shows the variation of electric field E due to a hollow spherical conductor of radius R as a function of distance from the centre of the sphere?

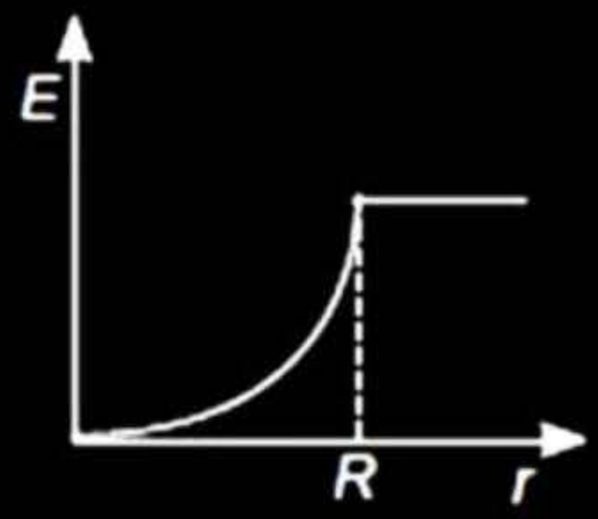
A



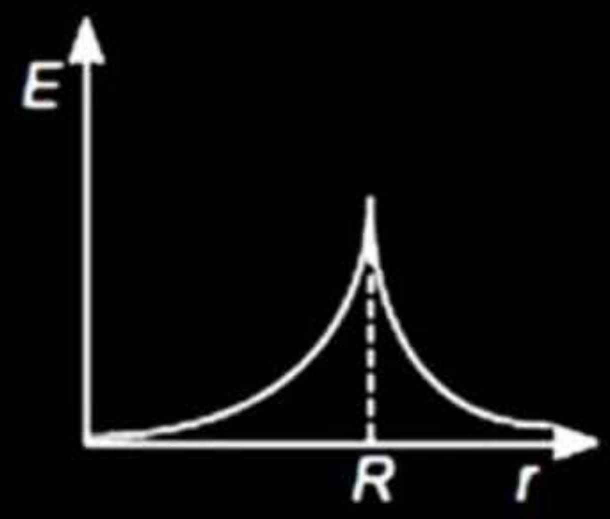
B



C



D

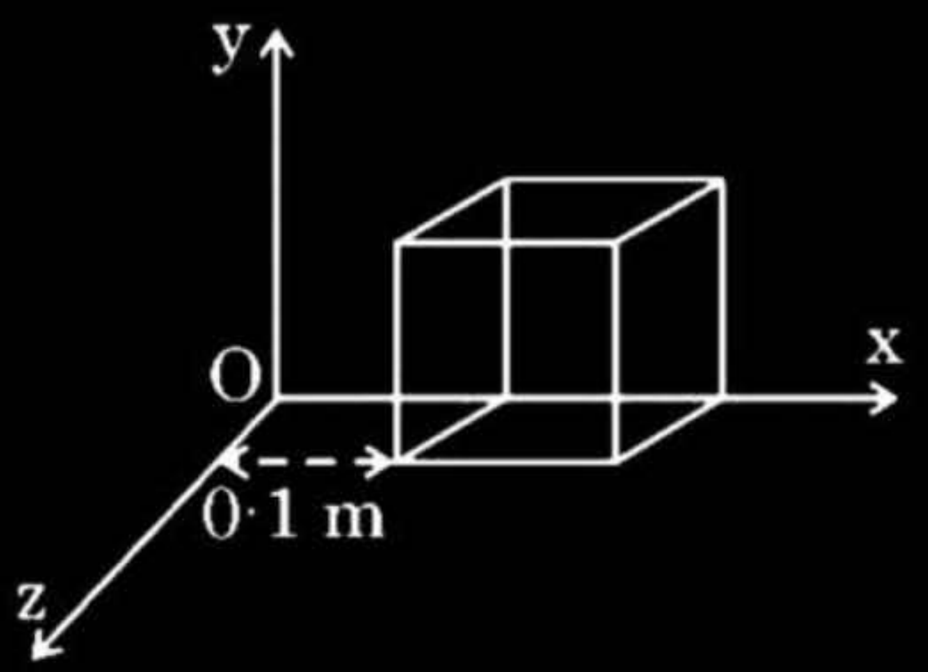


An electric dipole is placed at an angle of $60°$ with an electric field of intensity 10^5 N/C. It experiences a torque equal to $8\sqrt{3}$ Nm. Calculate the charge on the dipole, if the dipole length is 2 cm.

A cube of side 0.1 m is placed, as shown in the figure, in a region where electric field $\vec{E} = 500x\,\hat{i}$ exists. Here x is in meters and E in N^{-1}. Calculate:

(i)The flux passing through the cube, and

(ii)The charge within the cube.

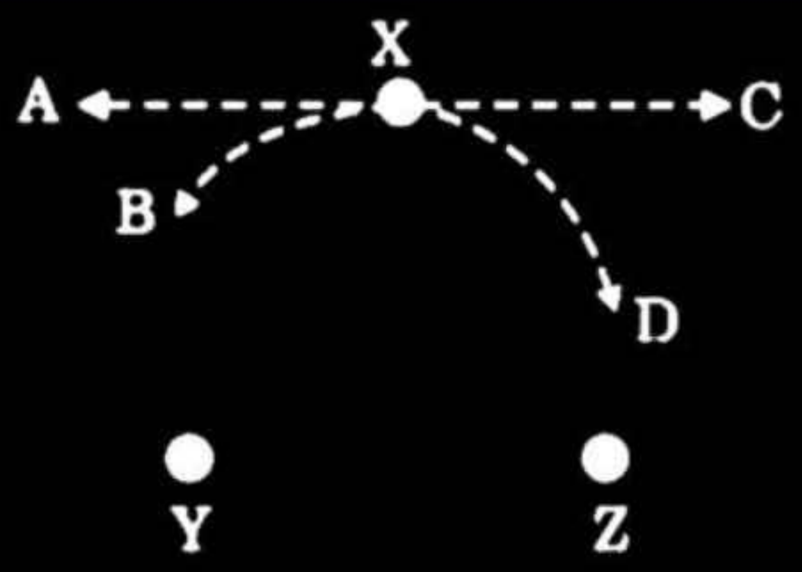


(i)A charge +Q is placed on a thin conducting spherical shell of radius R. Use Gauss's theorem to derive an expression for the electric field at a point lying (i) inside and (ii) outside the shell.

(ii)Show that the electric field for same charge density (σ) is twice in case of a conducting plate or surface then in a non-conducting sheet.

An electric dipole consists of point charges –1.0 pC and +1.0 pC located at (0, 0) and (3 mm, 4 mm) respectively in x-y plane. An electric field $\vec{E} = \left(\frac{1000\,\mathrm{V}}{\mathrm{m}}\right)\hat{i}$ is switched on in the region. Find the torque $\vec{\tau}$ acting on the dipole.

Three small charged spheres X, Y and Z carrying charges +q, –q and +q respectively are placed equidistant from each other, as shown in the figure. The spheres Y and Z are held in place. Initially X is also held in place, but is otherwise free to move. When X is released, the path followed by it will be:



A. A

B. B

C. C

D. D

What will be the ratio of the surface charge density of the inner surface to that of the outer surface of a hollow conducting sphere if a point charge is placed at the centre of the hollow conducting sphere having internal radius ‘r’ and outer radius ‘2r’?

An electric dipole consists of two opposite charges each of 10^{-1} C separated by 0.5 cm. If dipole is placed in an external uniform field of 10^{6} NC^{-1}, how much work is done in rotating the dipole through 180°, (starting from the position $\theta = 0°$)?

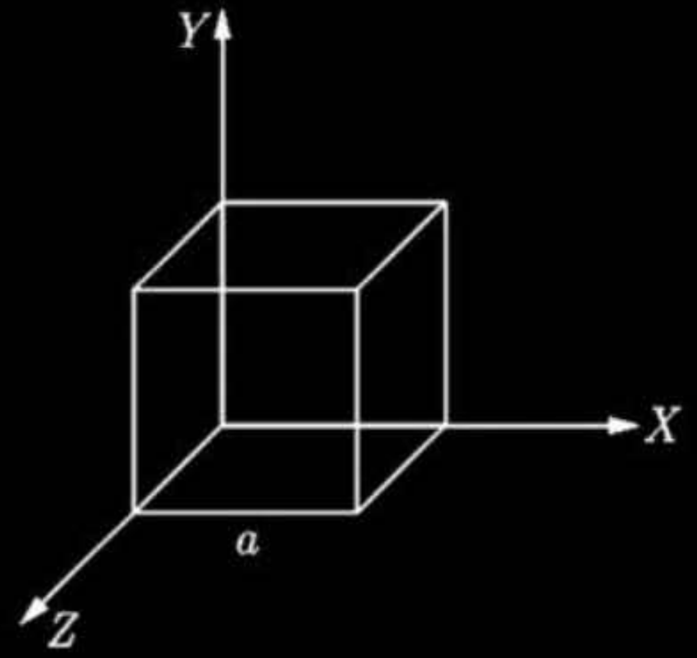
A sphere of lead of mass 10 g has net charge -2.5×10^{-9} C.

(i)Find the number of excess electrons on the sphere.

(ii)How many excess electrons are per lead atom? Atomic number of lead is 82 and its atomic mass is 207 g/mol.

(i) An electric dipole of dipole moment p consists of point charges +q and –q separated by a distance 2a apart. Deduce the expression for the electric field E due to the dipole at a distance x from the centre of the dipole on the axial line in terms of the dipole moment p. Hence, show that in the limit x >> a, $E = \dfrac{2p}{4\pi\varepsilon_0 x^3}$

(ii)Given the electric field in the region E = 2xi, find the net electric flux through the cube and the charge enclosed by it.



(i)Why must electrostatic field at the surface of a charged conductor be perpendicular to every point on it?

(ii)Draw lines of force of electric field due to a system of two equal point charges.

(iii)Why must electrostatic field at the surface of a charged conductor be normal to the surface at every point? Give reason.

1. Electric Chrages & Field

$Q = \pm Ne$

Properties :

- additive
- Conservative
- quantisation
- Invariant
- Attraction/Repulsion

Methods of charging :

- Friction
- Conduction
- Induction

Coulomb's Law

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

$$k = \frac{1}{4\pi\varepsilon_0}$$

$$\varepsilon_m = \varepsilon_0 \varepsilon_r$$

$$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/Nm^2}$$

$$k = 9 \times 10^9\ \mathrm{N\,m^2/C^2}$$

$$\vec{\mathbf{F}}_{net} = \vec{\mathbf{F}}_1 + \vec{\mathbf{F}}_2 + \cdots$$

$$\mathbf{E} = \frac{\mathbf{kQ}}{\mathbf{R^2}}$$

$$\mathbf{F} = \mathbf{qE}$$

Electric Field lines

Field line properties

$$\mathbf{p} = \mathbf{q}\,2l$$

$$\mathbf{E_{net}} = \frac{\mathbf{2kp}}{\mathbf{r^3}}\ (\text{axial})$$

$$\mathbf{E_{net}} = \frac{\mathbf{kp}}{\mathbf{r^3}}\ (\text{equatorial})$$

Torque on a dipole :

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

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

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

$$\tau_{\min} = -\mathbf{pE}$$

Charge distribution :

$$\lambda = \frac{\mathbf{q}}{\mathbf{L}}$$

$$\sigma = \frac{\mathbf{q}}{\mathbf{A}}$$

$$\rho = \frac{\mathbf{q}}{\mathbf{V}}$$

Electric Field due to

1. **Ring at centre**

$$\mathbf{E} = \mathbf{0}$$

2. **Outside the ring**

$$\mathbf{E} = \frac{\mathbf{kQ}}{\mathbf{r^2}}$$

Electric Flux :

$$\phi = \mathbf{EA}\cos\theta$$

Gauss Theorem :

$$\oint \vec{\mathbf{E}} \cdot \mathbf{d}\vec{\mathbf{A}} = \frac{\mathbf{q}_{\text{in}}}{\varepsilon_0}$$

Electric Field due to

1. **Infinite long wire**

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

2. **Infinite sheet**

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

3. **Conducting shell**

- **Inside conductor** $\mathbf{E} = \mathbf{0}$
- **Outside** $\mathbf{E} = \frac{\mathbf{kQ}}{\mathbf{r^2}}$
- **Surface** $\mathbf{E} = \frac{\mathbf{kQ}}{\mathbf{r^2}}$

Thank You