Electromagnetism

Electrostatics (charge stationary)

Electrodynamics
- electric current
- magnetism
- emi, Ac.

Charge

→ intrinsic property.
↓
very fundamental quantity

symbol - Q
unit - coloumb.
type - Scalar

Two types

+ve -ve

Like charges repel
unlike charges attract

Conservation of charge

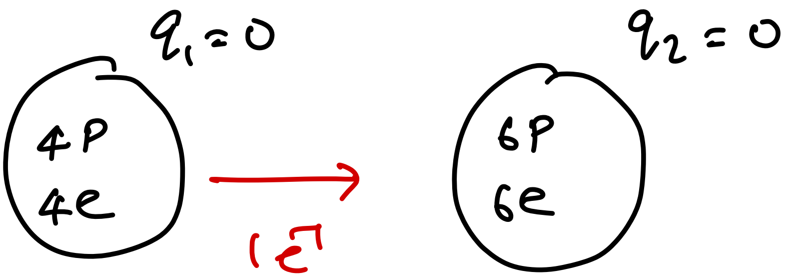
Charge of an isolated system is constant.

↓ (system) not a body but a system

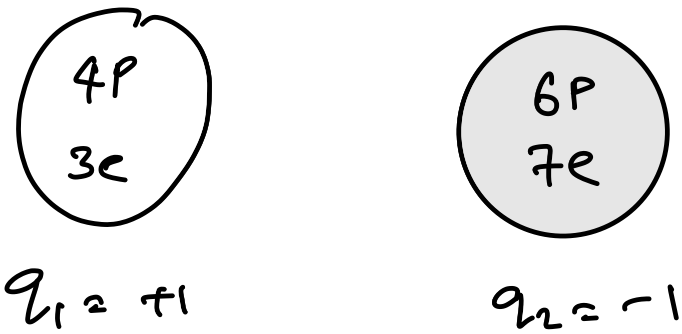
We need to get a feel of it.

How do we get charge? → when electron transfers from one body to another.

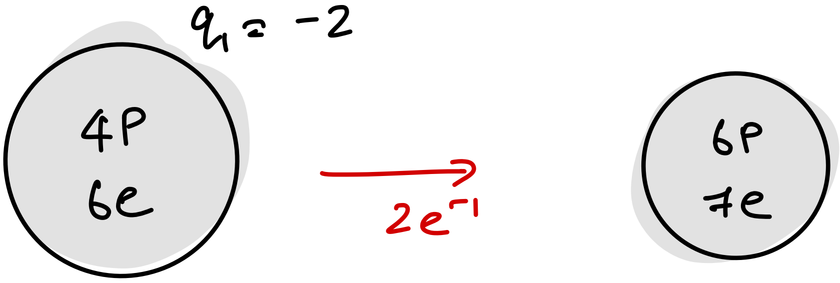
From proton and electron.



$q_1 + q_2 = 0 + 0$
$= \underline{\underline{0}}$

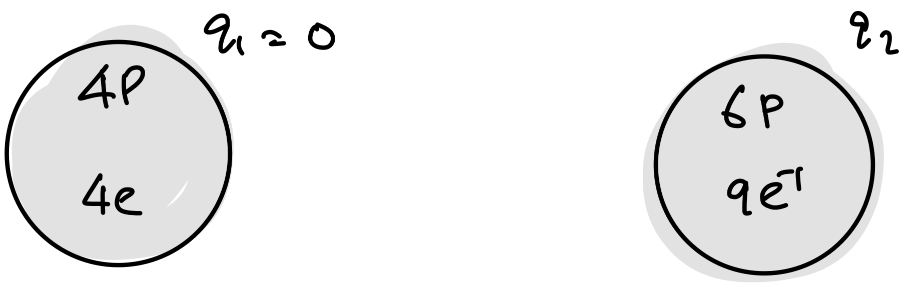


$q_1 + q_2$
$= +1 - 1 = \underline{\underline{0}}$



$q_1 + q_2 =$

$-2 - 1 = \underline{\underline{-3}}$



$q_1 + q_2$

$= 0 - 3 = \underline{\underline{-3}}$

Quantization of Charge

{ Available is fixed amount }

i) The smallest charge that can exist independently is charge is e^{-1}

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

1e, 2e, 3e, 4e....

-1e, -2e, -3e, -4e...

$Q = \pm ne$

Q) Can a charge of $1.8 \times 10^{-18} C$ be given to a body?

Charging by Conduction → direct contact

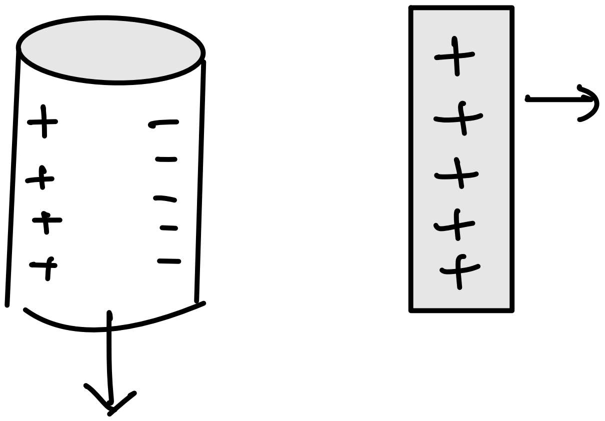
A body charged by having direct contact with another body.

eg:- Scale and hair + papers

silk thread + plastic rod

silk thread + glass rod

Charging by Induction → no direct contact



Polarization of charges.

When a high positive charge brought near a body negative charges tend to concentrate to one side thus creating a Polarization of charges.

Important Questions

Board exam perspective

1) What does $q_1 + q_2 = 0$ signify in electrostatics?

2) What kind of charges are produced when a glass rod is rubbed with silk?

3) Can a body have charge of 0.8×10^{-19} C. Justify your answer with proper explanations.

4) Give any Two points of difference bet'n charge & mass

5) Explain:- Charging by Induction
Charging by Conduction.

6) List 6 properties of electric charge

Numericals – Level 1.

1) Find the total charge in the system containing +1, +2, +4, −5, −2. (in μC)

2) A metal sphere has a charge of −6μC. If 5×10^{12} e^{-1} are removed from it, what is the final charge?

3) How many electrons are needed to achieve 1C of electric charge?

Coloumbs law

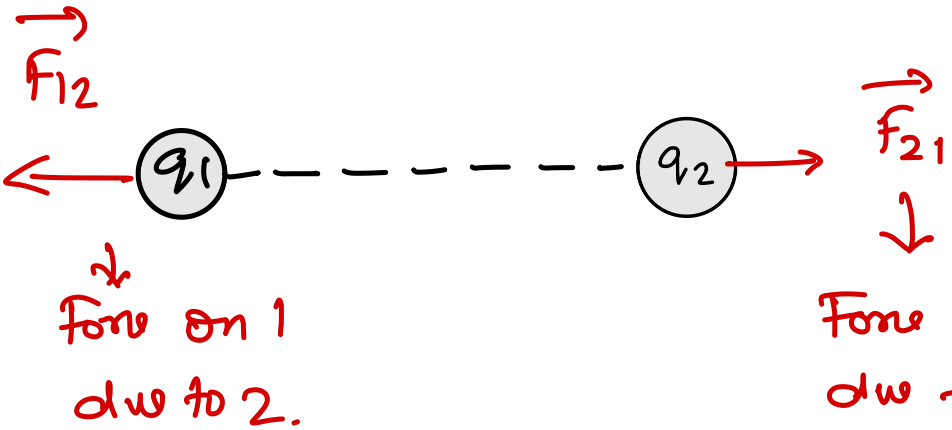
* we know that like charges repel
  unlike charges attract.

* purpose of Coloumbs law is to quantify this force.

Statement

The force of attraction bet'n two charges is directly proportional to product of the charges and inv. prop. to the square of the distance bet'n them.

$F \propto q_1 q_2$ and $F \propto \frac{1}{r^2}$



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

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

The value of K is equal to

> 9×10^9
> for air / vaccum.

The value (K) changes from one medium to another.

Numericals - Level 1

1) What is the force bet'n two charged spheres having charges 2×10^{-7} C and 3×10^{-7} C placed 30cm apart in air?

2) The electrostatic force bet'n two spheres of charge 0.4 μC and -0.8 μC is 0.2 N. Find the

   a) distance bet'n charges

   b) Nature and value of force on 2^{nd} sphere due to first.

3) A free pith ball of 8g carries a +ve charge of 5×10^{-8} C. What must be the nature and magnitude of charge to be given to a second ball placed 5 cm below the first ball so that it remains stationary.

Board exam perspective Questions.

① If the distance between two equal point charges are doubled, and their individual charges are also doubled, what would happen to the force between them?

② Define coloumb as a unit charge

(or)

Define SI unit of charge.

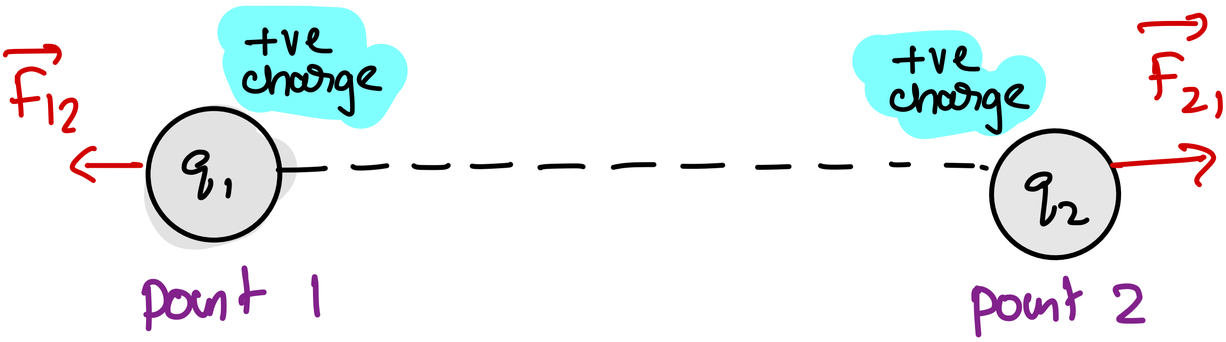
③ Two charges are given such that $q_1 q_2 < 0$, what is the nature of force between them?

④ What are the conditions for applying Coloumbs law? → central + stationary

⑤ State coloumbs law in electrostatics. Mention the similarities and dissimilarities between electrostatic and gravitational force

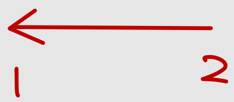
⑥ Express Coloumbs law in vector form with the help of diagram

Vector form



$\vec{F}_{12} \rightarrow$ Force on q_1 due to q_2

This is directed from ② to ①



Initial point → 2 final point → 1

$\Rightarrow \vec{r}_{21} = \vec{r}_1 - \vec{r}_2$

$\vec{r}_{21}$ ↓ Disp vector

$\vec{r}_1$ ↓ final point

$\vec{r}_2$ ↓ Initial point

$\vec{F}_{21} \longrightarrow$ force on q_2 due to q_1

This is directed from ① to ②

Initial point → 1 final point → 2

$\vec{r}_{12} = \vec{r}_2 - \vec{r}_1$

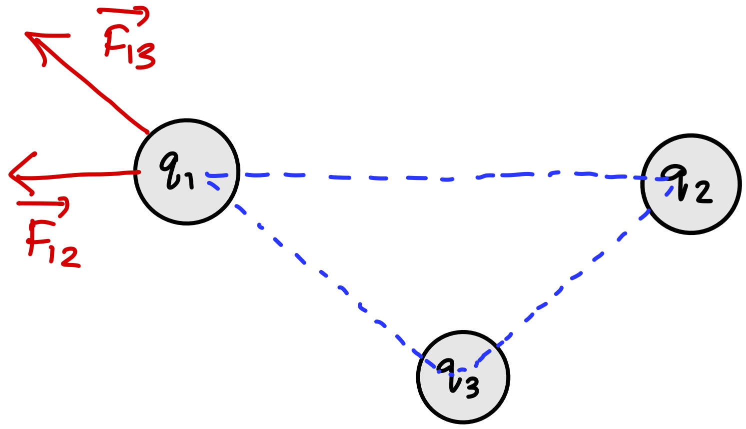
$\vec{r}_{12}$ ↓ Disp. vector

$\vec{r}_2$ ↓ final point

$\vec{r}_1$ ↓ Initial point

Principle of Superposition

This is to be considered when we have multiple charges placed near each other.



Here charge q_1 experiences two forces due to charge q_2 and q_3.

$\vec{F}_{12}$ – Force on q_1 due to q_2

$\vec{F}_{13}$ - Force on q_1 due to q_3

Net force on q_1 is

$$\vec{F}_{net} = \vec{F}_{12} + \vec{F}_{13}$$

Numerical Problems- Level 1

① Three charges 10 μC, 5μC and −5μC are placed in air at the three corners A, B, C of an equilateral triangle of side 10cm. Find the force exp. by charge placed at corner A.

② ABC is an equilateral triangle of side 10m. D is the mid point of BC. Charges of 100, −100, 75 C. are placed at B, C, D respectively. What is force experienced by 1C positive charge placed at A?

From moder ABC Pg 21,

1, 2, 3, 7, 8, 13, 14, 18, 24, 25,
26, 27, 30

Concept of permittivity

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

$$K = \frac{1}{4\pi\varepsilon}$$

$\varepsilon \rightarrow$ permittivity of medium

Property of medium that allows the electric field to reduce force bet'n charges.

i.e $\varepsilon\uparrow \Rightarrow F\downarrow$ or

$\varepsilon\downarrow \Rightarrow F\uparrow$

Some one who controls the force bet'n charges.

i.e $F \propto \frac{1}{\varepsilon}$

$\varepsilon \rightarrow$ minimum for vaccum / air

$F \rightarrow$ max. for vacuum / air.

$\varepsilon_{med} > \varepsilon_{air}$

$\Rightarrow F_{med} < F_{air}$

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

Relative Permittivity (Dielectric constant)

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

→ Ratio of permittivity of any medium to permittivity of vaccum / air.

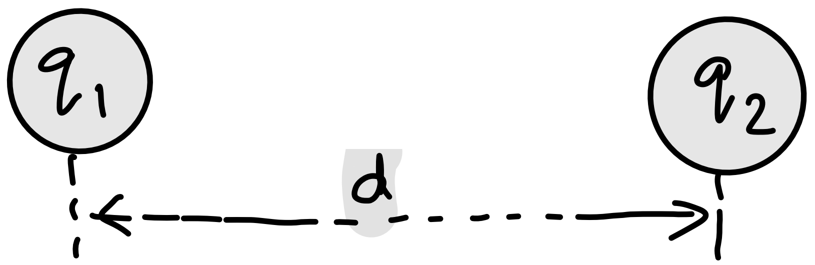
Since ε_0 has min. value of ε,

$\varepsilon_r > 1$

$\varepsilon_r = 81$ → This means force reduces by 81 times

$\varepsilon_r = 9$ → force reduces by 9 times

Problem



If distance bet'n charges is halved, and med. is changed. Force is also halved. Find ε_r of medium.

Ans → $\varepsilon_r = 8$

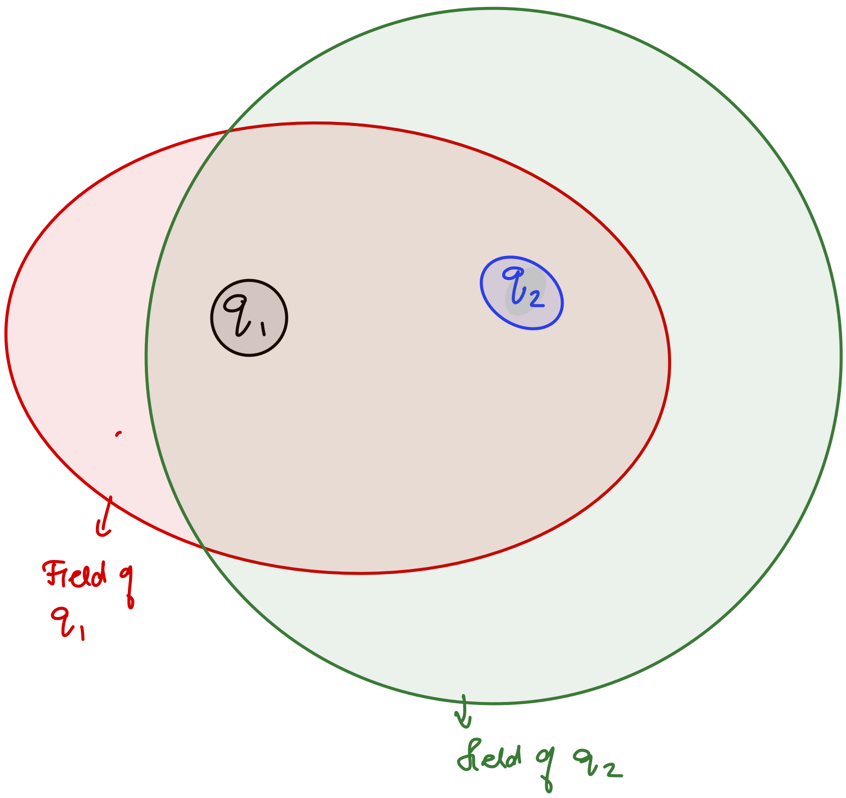
Electric Field

A charge creates a field around it called electric field.

When another charge is brought onto this field, it experiences a force, which is quantified by coloumbs law.

Definition:-

electric field due to a charge is the space around the charge in which any other charge placed will experience an electrostatic force.



Electric Field Lines

As we go far away influence of charge reduces

$\left(E \propto \frac{1}{r^2}\right)$

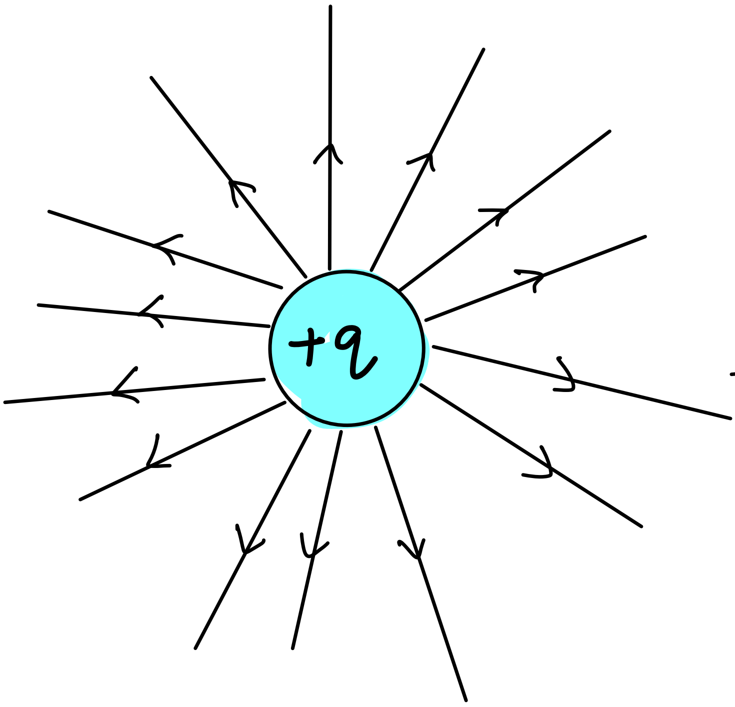
(q)

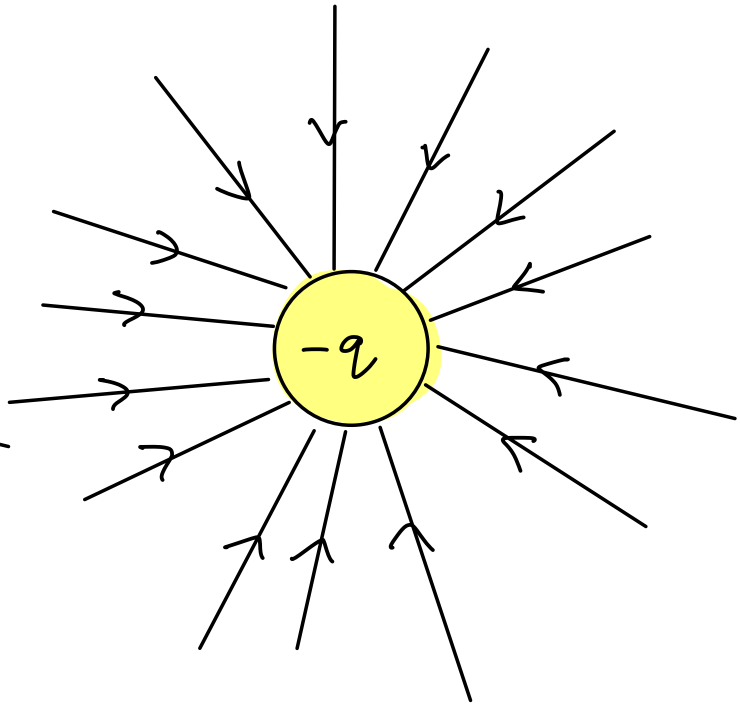
Field is more powerful near charge

Influence of charge given by Electric Field intensity

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

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





For positive charge the field lines are towards outside.

→ radially outward

For negative charge the field lines are towards inside

→ radially inwards

Concept of electric field Intensity

Def:- Electric field intensity at a point is the force experienced per unit positive test charge placed at that point w/o disturbing / changing the position of the source charge

SI unit $= \frac{\text{Force}}{\text{charge}}$

$= \frac{N}{C}$

$= NC^{-1}$

Electric Field due to a point charge at any given point

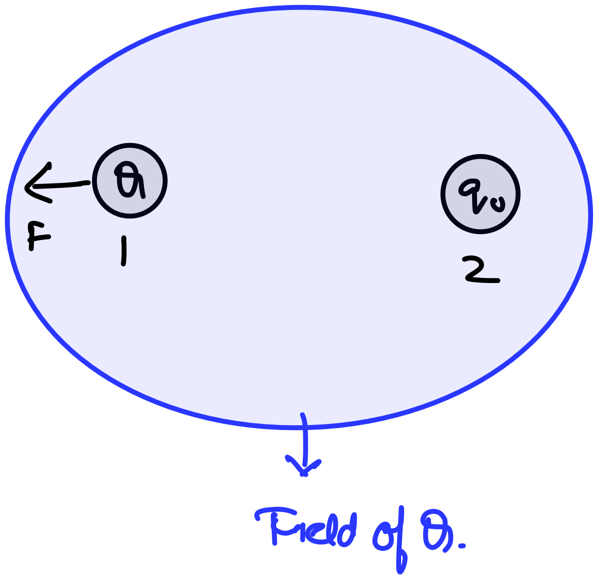
$$\vec{E} = \frac{\vec{F}}{q_0}$$

$q_0 \rightarrow$ test charge

$Q \rightarrow$ source charge

$$\Rightarrow \vec{E} = \frac{K Q q_0}{r^2} \times \frac{1}{q_0}$$

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



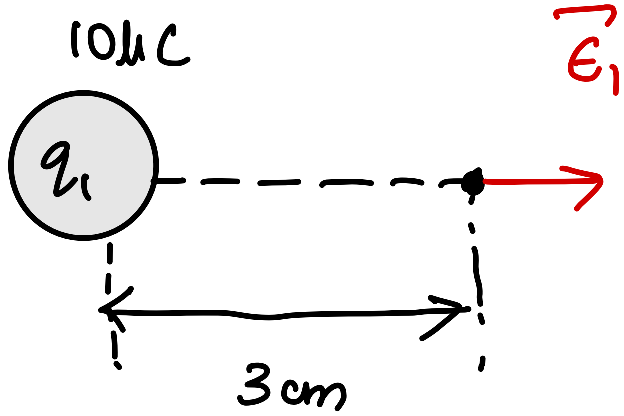
$$\Rightarrow \boxed{\vec{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{r^2}}$$

Vector form:-

$$\boxed{\vec{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{|\vec{r}_1 - \vec{r}_2|^3} \times (\vec{r}_1 - \vec{r}_2)}$$

Let us understand the Concept with the help of a problem.

Find the electric field intensity by $10\mu C$ of charge at a point 3 cm from the charge as shown on figure.

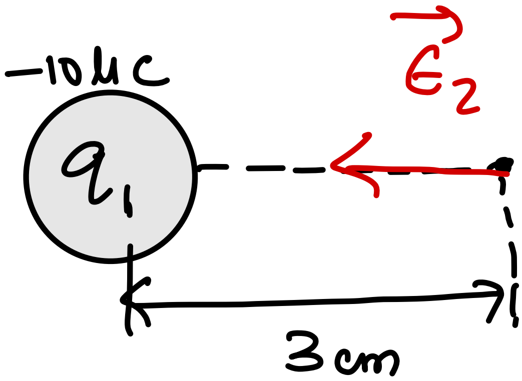


$$\vec{E_1} = K \times \frac{q_1}{r^2}$$

$$= \frac{9\times10^9 \times 10\times10^{-6}}{(3\times10^{-2})^2} = \frac{9\times10}{9} \times \frac{10^9\times10^{-6}}{10^{-4}}$$

$$= 10\times10^7 = 10^8 \ N/C$$

Find the electric field intensity by $-10\mu C$ of charge at a point 3 cm from the charge as shown on figure.

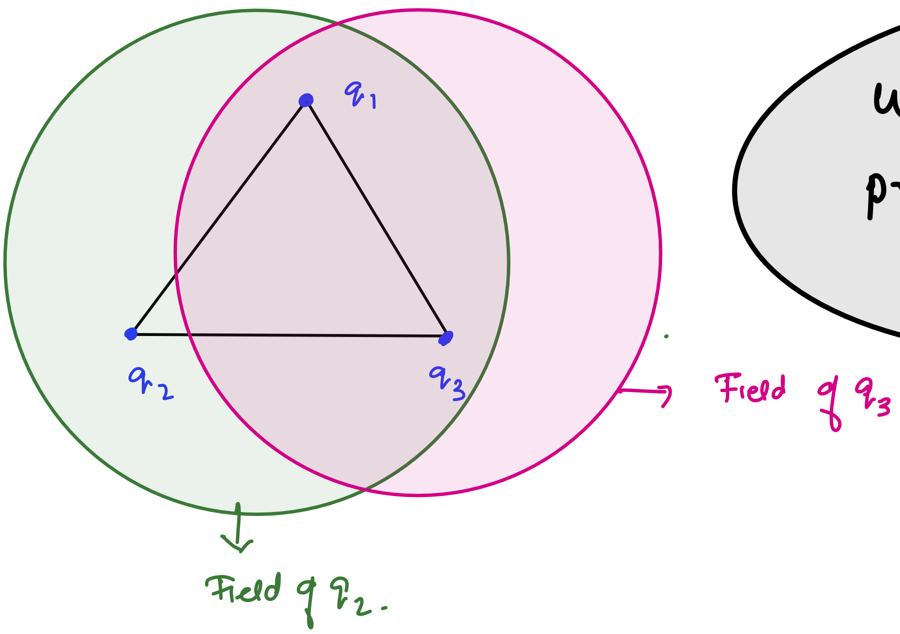


$$\vec{E_2} = K \times \frac{q_2}{r^2} = \frac{9\times10^9 \times 10\times10^{-6}}{(3\times10^{-2})^2} = 10^8 \ N/C$$

> In above two questions we found intensity of electric field at a point in the electric field

Electric Field due to discrete distribution of Charges.

meaning of discrete distribution of charges } → Many charges placed at diff positions.



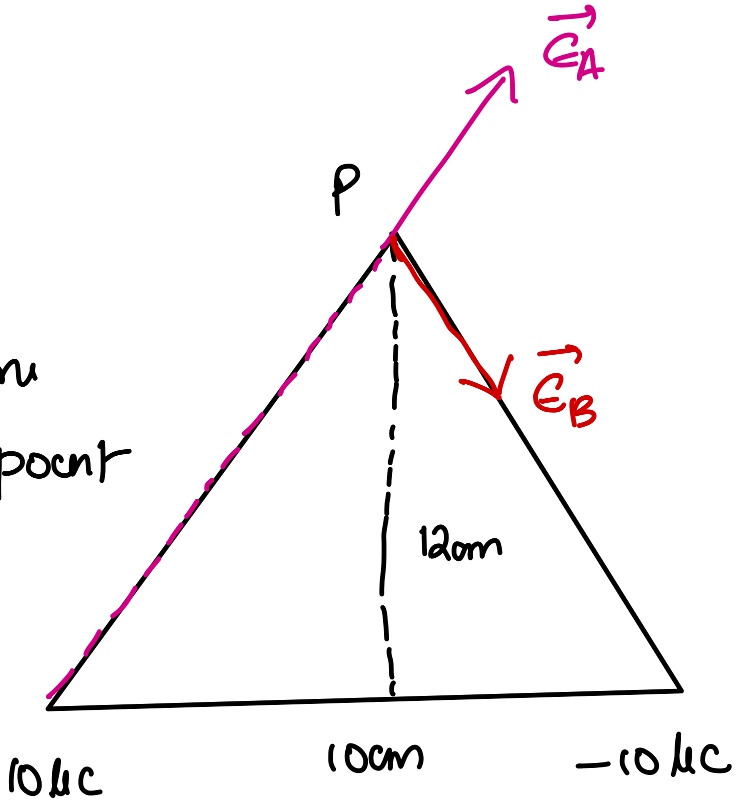
We can see that q_2 is present in the field of q_1 and q_3

So, we can understand that charge q_2 will experience force due to field from q_1 and q_3

In such situations we make use of concept of principle of superposition.

Let us understand the concept with the help of a problem.

Q1) Two charges A and B of values 10 μC and −10 μC, are kept 10 cm apart. Find the electric field intensity at a point P on the ⊥r bisector of AB at a distance 12 cm from its mid point.



Electric Field Lines

As we go far away influence of charge reduces

$\left(E \propto \frac{1}{r^2}\right)$

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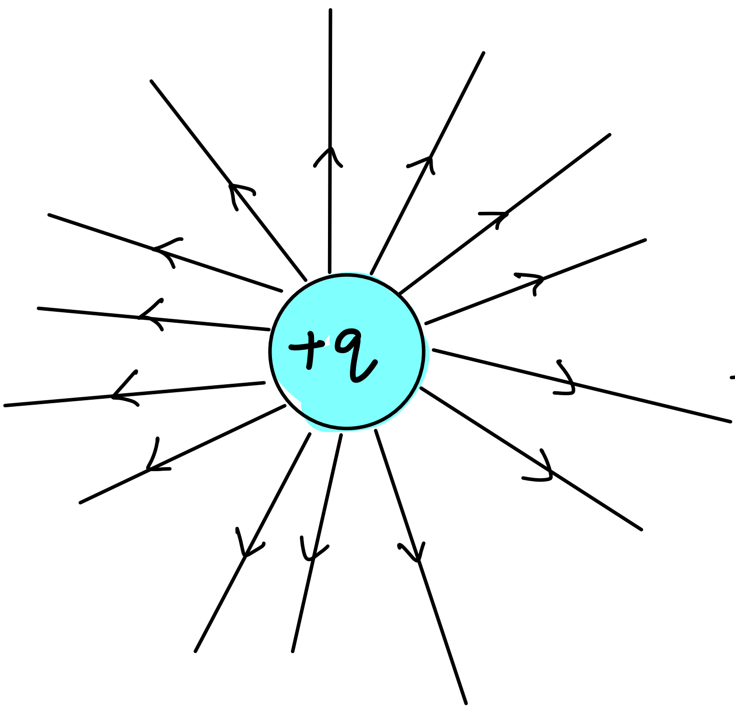
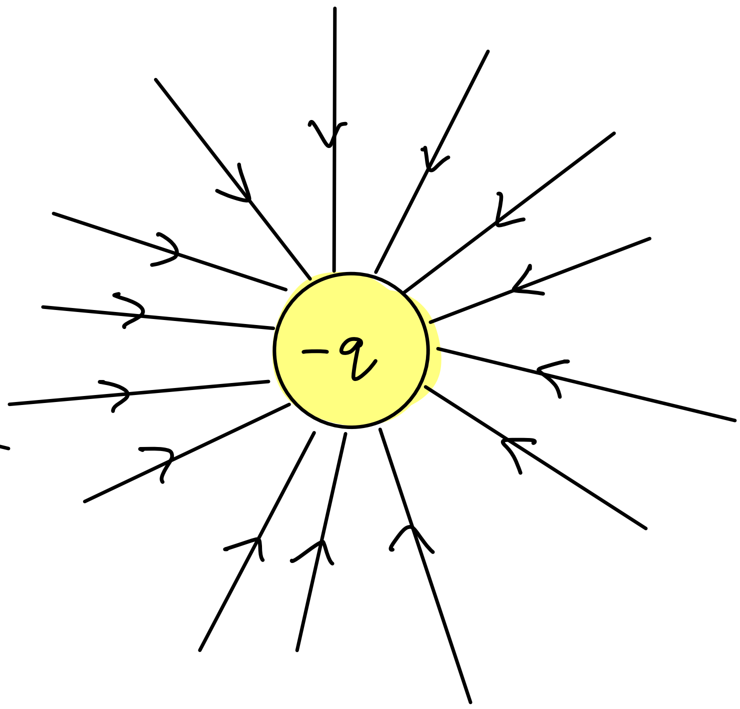
$$\Rightarrow E \propto \frac{1}{r^2}$$





For positive charge the field lines are towards outside.

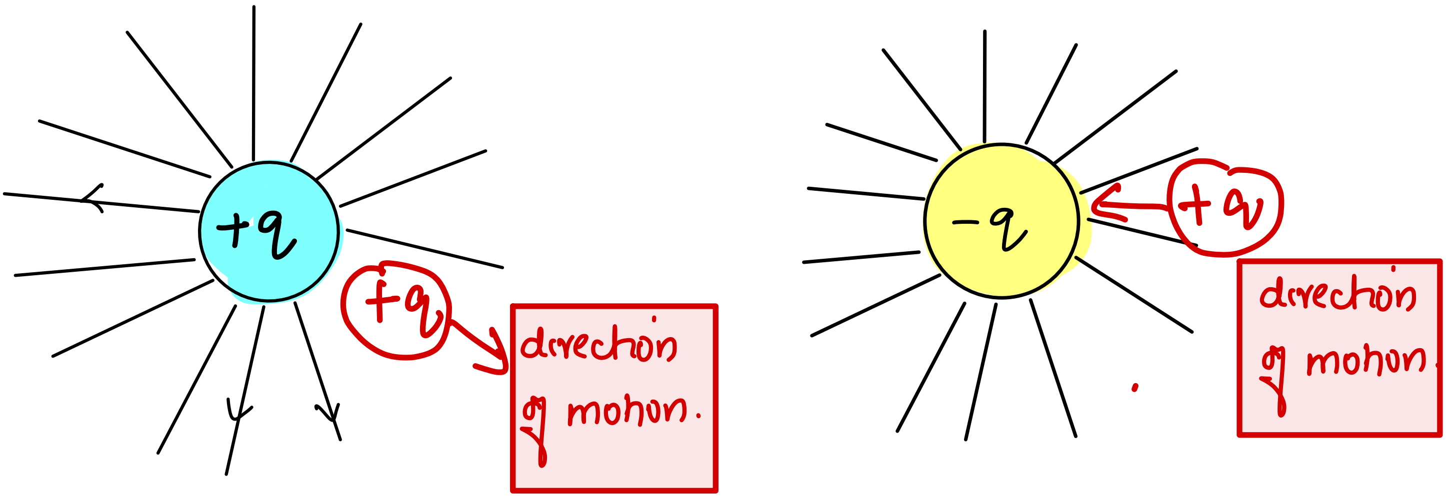
→ radially outward

For negative charge the field lines are towards inside

→ radially inwards

Properties of Electric Field Lines

1) Field lines are 'Imaginary' lines in a region of space and time along which a free positive charge would move if allowed to do so.



2) They originate at a positive charge and terminate at a negative charge.

3) They do not form a closed loop.

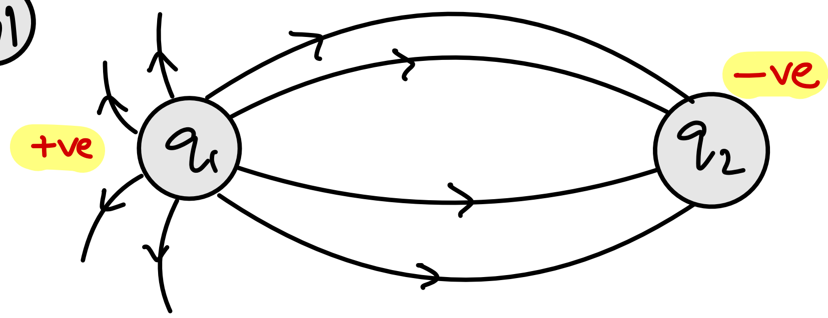
4) They do not terminate in space

5) The number of field lines are subjective but the density of field lines is objective

6) The no. of field lines from/to a charge

$\propto$ |Magnitude of charge|

Q1



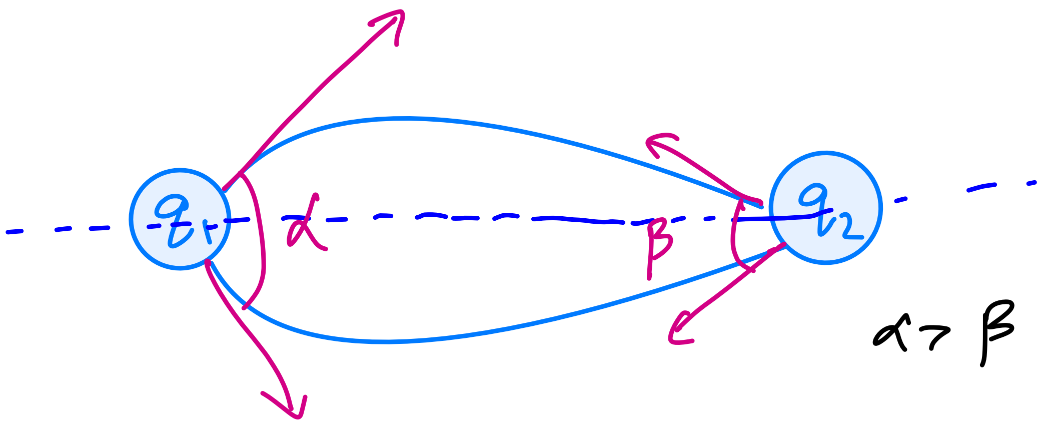
Find the value of $\frac{q_1}{q_2} = ?$

$$\frac{|q_1|}{|q_2|} = \frac{+8}{-4} = -2$$

a) 2   c) −1/2
b) 1/2   d) −2

Q2 The field lines are symmetric about the line joining two charges.

Find which is greater value q_1 or q_2

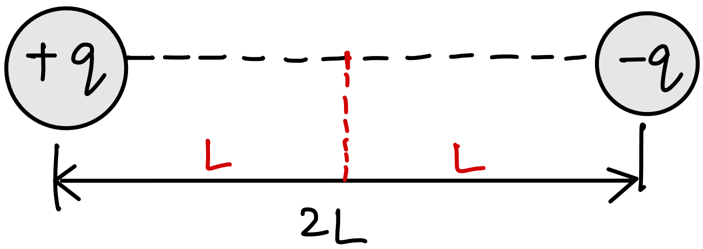


$\alpha > \beta$

density of field lines in q_1 is less when compared q_2. So q_2 has higher value

Electric Dipole

Two equal and opposite charges separated by a small distance



Dipole moment

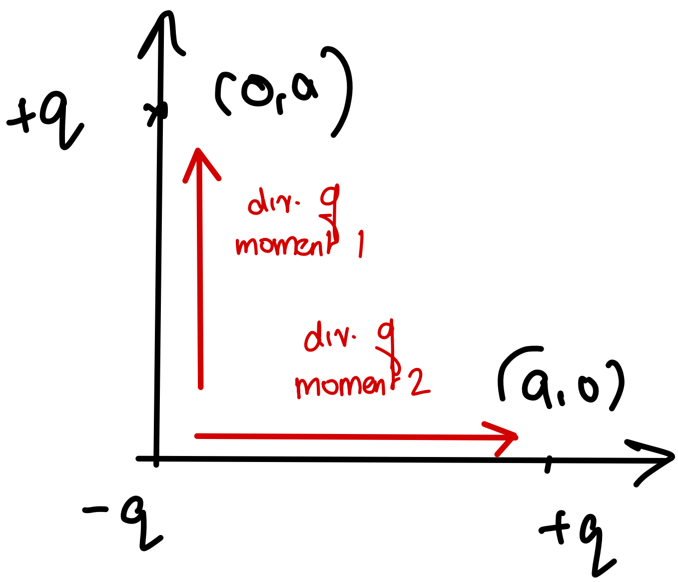
SI unit → Cm

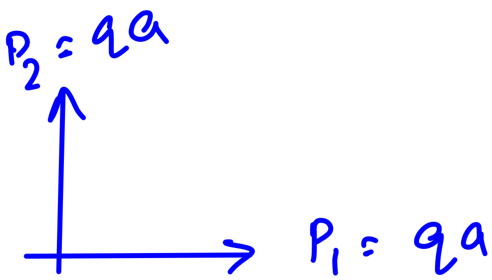
Definition — product of → | one of the charges × distance bet'n charges |

This is a vector quantity.

Equation → $p = q \times 2L$

Q1 Find the net dipole moment for the system.





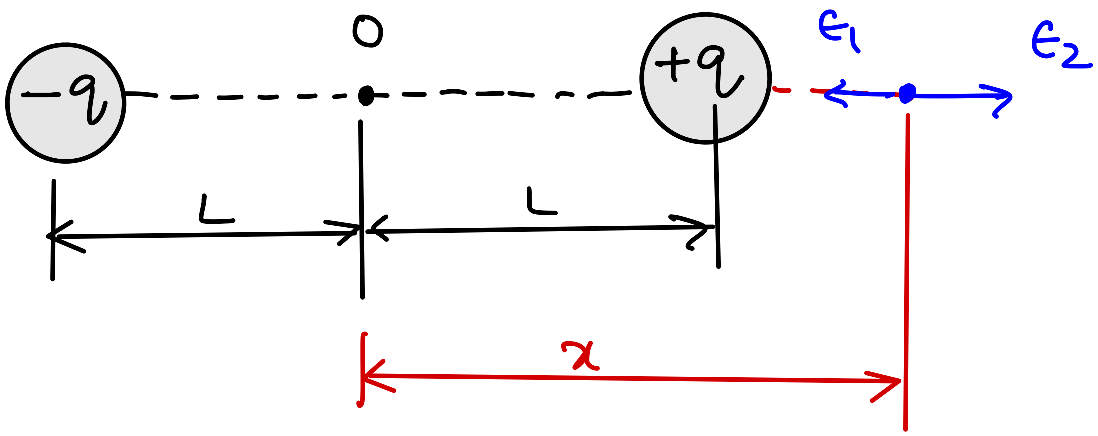
$P_{net} = \sqrt{P_1^2 + P_2^2}$

$P_{net} = \sqrt{2}\, qa$

Electric Field due to dipole

→ on the axis of the dipole.

→ at distance x from centre of dipole.



It is logical to say $E_2 > E_1$.

(distance to x from +q is less than −q)

$$E_1 = \frac{kq}{(x+L)^2} \qquad E_2 = \frac{kq}{(x-L)^2}$$

$$E_{net} = E_2 - E_1 = kq\left[\frac{1}{(x-L)^2} - \frac{1}{(x+L)^2}\right]$$

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

$$= Kq\left[\frac{4xL}{(x^2-L^2)^2}\right] = \left[2Kq\,\frac{2xL}{(x^2-L^2)^2}\right]$$

$$\Rightarrow \quad E_{net} = \frac{(q\,2L)\,K \times 2x}{(x^2-L^2)^2} = \frac{2Kpx}{(x^2-L^2)^2}$$

Generally $x \gg l \Rightarrow l^2 \approx 0$

$$\Rightarrow \quad E_{net} = \frac{2Kp\,x x}{x^4} \Rightarrow \boxed{E_{net} = \frac{2Kp}{x^3}}$$

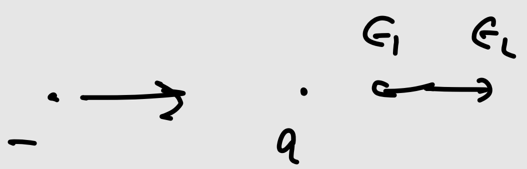
electric field due to a dipole along axis is given by $\frac{2Kp}{x^3}$.

vector form.

$$\vec{E} = \frac{2K\vec{p}}{x^3}$$

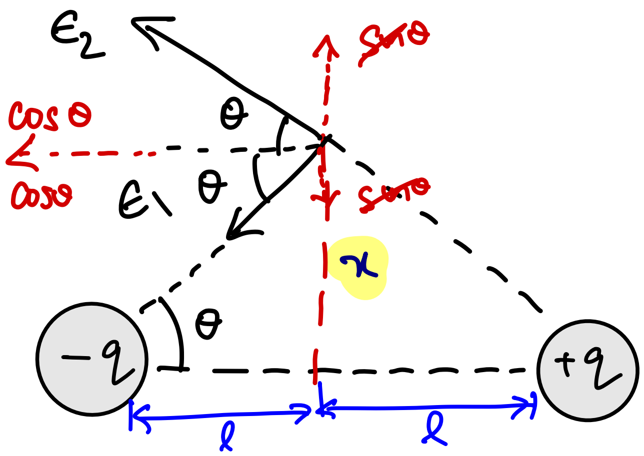
dir. of dipole moment due to right

This is the direction of electric field when point is near to +ve charge



$E_2 > E_1 \Rightarrow E_2$

Electric Field due to dipole



→ on ⊥r bisector of dipole

→ at distance x from centre of dipole.

$$E_1 = \frac{Kq}{r^2} = \frac{Kq}{x^2+l^2}$$

$$E_2 = \frac{Kq}{r^2} = \frac{Kq}{x^2+l^2}$$

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

$$= \frac{Kq}{x^2+l^2} \times 2\cos\theta$$

$$= \frac{Kq}{x^2+l^2} \times 2 \times \frac{l}{\sqrt{x^2+l^2}}$$

$$= \frac{K \times (q \times 2l)}{(x^2+l^2)^{3/2}}$$

$$= \frac{Kp}{(x^2+l^2)^{3/2}}$$

$$E_{net} = \frac{Kp}{(x^2+l^2)^{3/2}}$$

but $x >> l$
⇓

$$E_{net} = \frac{Kp}{x^3}$$

Direction of E_{net}.

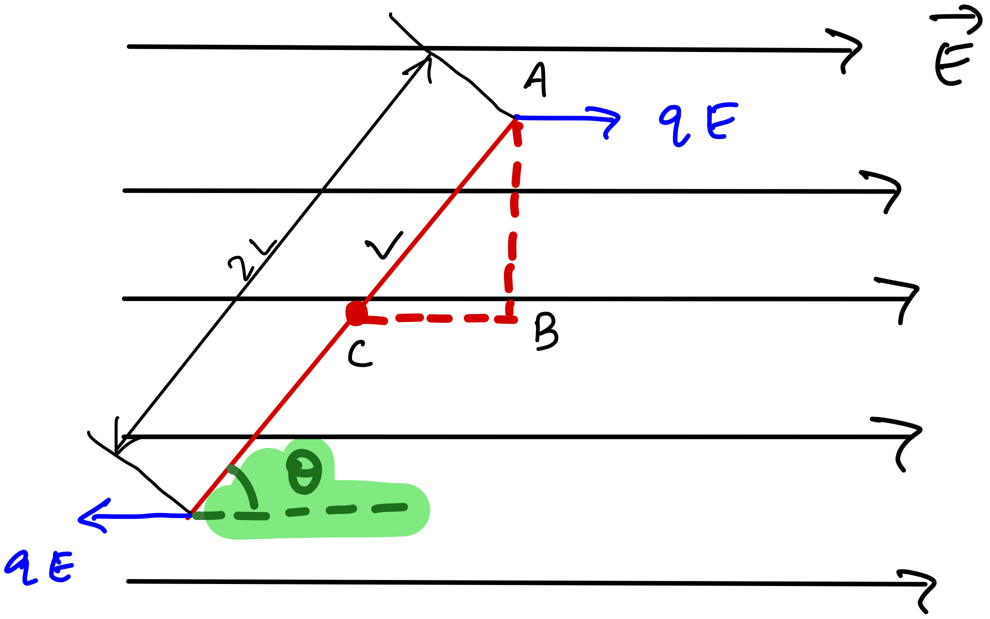
opp to $\vec{p}$

$$\vec{E} = -\frac{K\vec{p}}{x^3}$$

As a conclusion,

$$(E_{net})_{axial} = 2 \times (E_{net})_{equatorial}$$

Torque on an electric dipole placed in a uniform electric field.



The net force acting on the dipole in a uniform electric field = 0.

But a torque is produced here as two forces are positioned not along the same line of action. → Torque produced

Translational equilibrium ✓ Rotational eq ✗

Torque = Force × ⊥r distance

= $qE \times (AB)$ → see figure.

= $qE \times l\sin\theta$

But we have two forces,

⇒ $\tau = \tau_1 + \tau_2$

= $qEl\sin\theta + qEl\sin\theta$

= $q(2l)E\sin\theta$

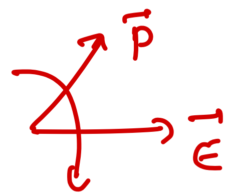
$$\tau = pE\sin\theta$$

Direction of $\vec{\tau}$

so, $\vec{p} \times \vec{E}$

or

$\vec{E} \times \vec{p}$.



⇒ accept

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

Q1 When is torque maximum?

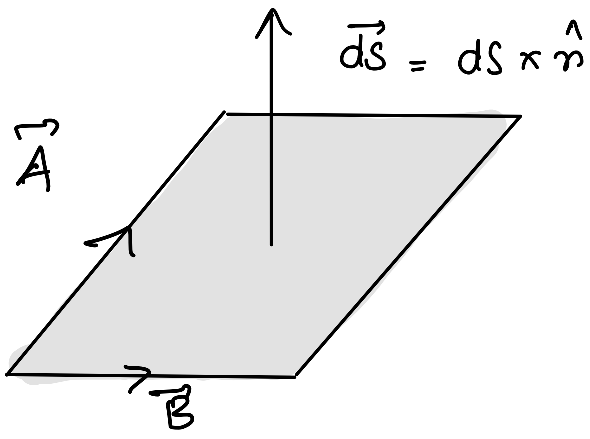
Q2 When is torque minimum/zero?

Stable equilibrium concept → return back

Unstable equilibrium concept → goes ahead

Concept of Area vector

$\hat{n} \rightarrow$ a unit vector ⊥r to surface.



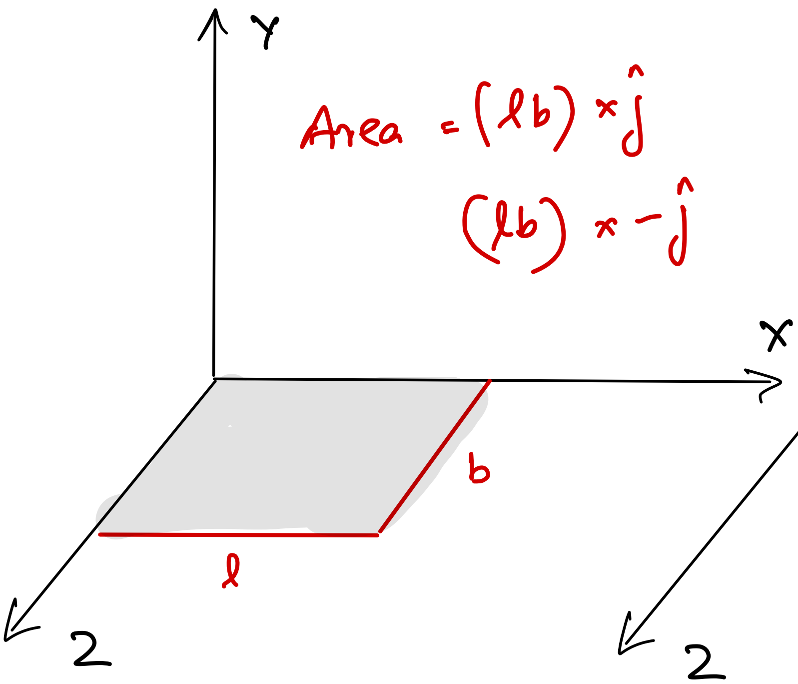
$\vec{ds} = \hat{n} \times ds$

$ds \rightarrow$ magnitude of area

$\hat{n} \rightarrow$ dir. of unit vector

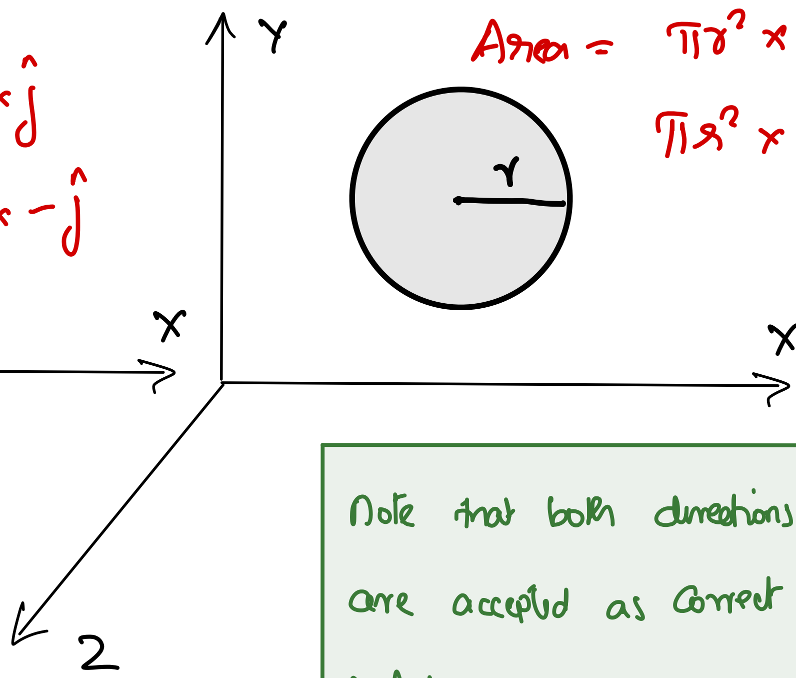
$|\vec{ds}|$ = area of shape

$\vec{A} \times \vec{B}$ = area vector (⊥r to $\vec{A}$ & $\vec{B}$)



Area = $(lb) \times \hat{j}$

$(lb) \times -\hat{j}$

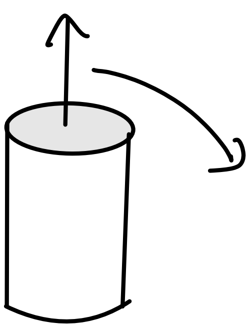


Area = $\pi r^2 \times \hat{k}$

$\pi r^2 \times -\hat{k}$

Note that both directions are accepted as correct values.

for open surfaces

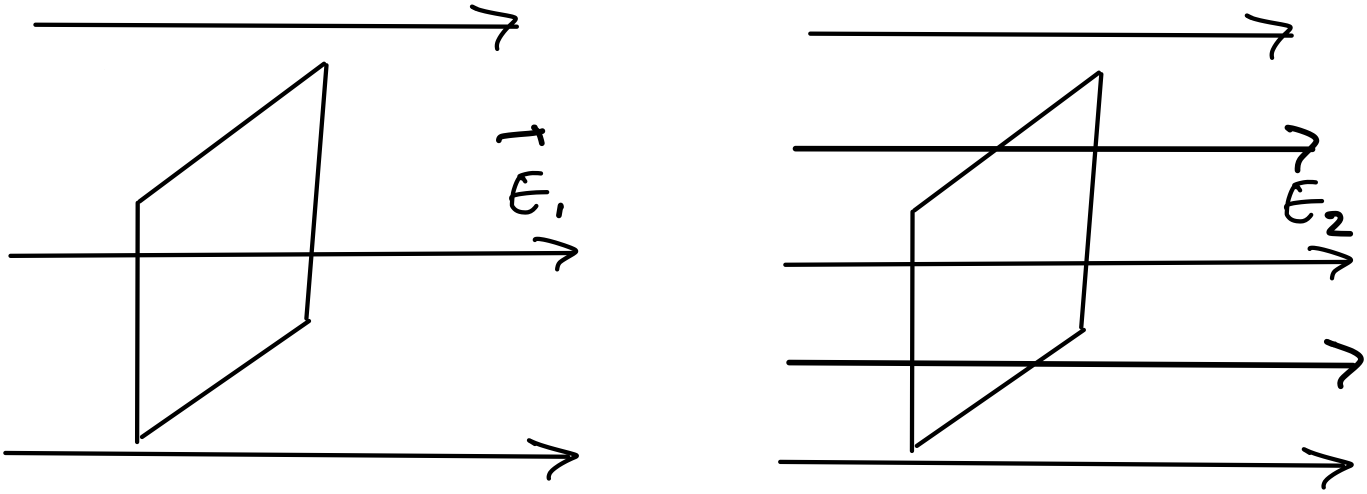


For closed surfaces we take the one going outside the volume

Electric Flux

Electric Flux through a surface inside an electric field represents the total no. of electric field lines of force crossing the surface in a direction normal to it.

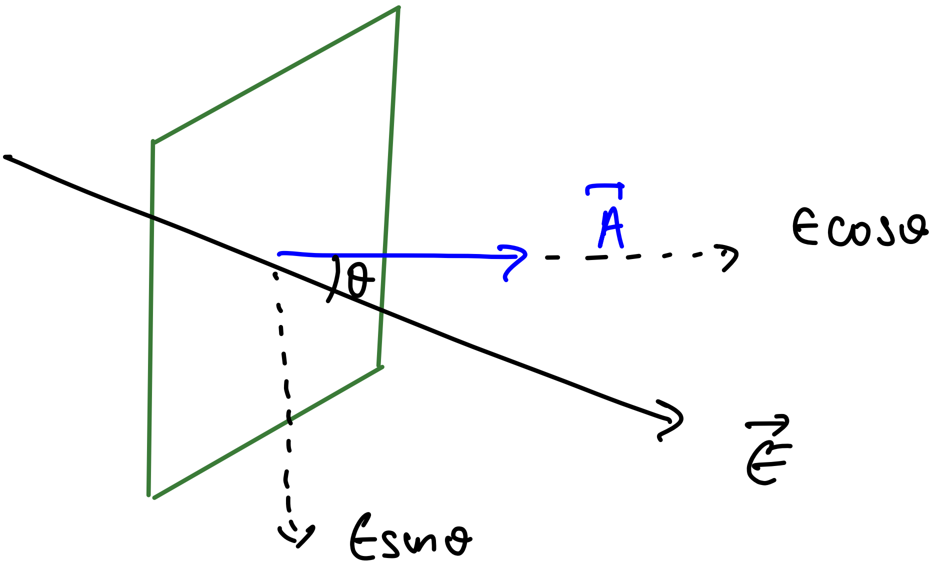
> The no. of electric field lines passing ⊥ly to a plane surface



> Density of field lines ∝ intensity of electric field → $E_2 > E_1$

Connect these concepts to connect

unit of electric flux – $N m^{2} C^{-1}$



E cosθ can create electric flux but no E sinθ (as it is ∥)

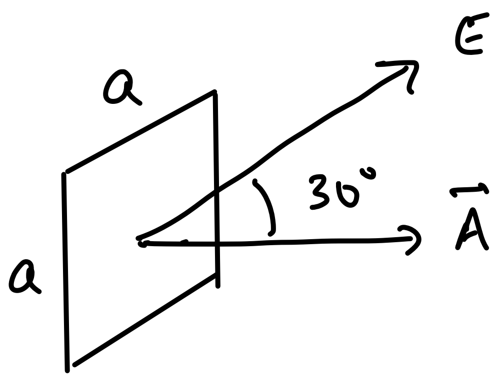
$$\Rightarrow \quad \phi_E = (E\cos\theta) \times A$$

$$= EA\cos\theta$$

$$\boxed{\phi_E = \vec{E}\cdot\vec{A}}$$

From this we can say that electric flux is a scalar quantity

Q1



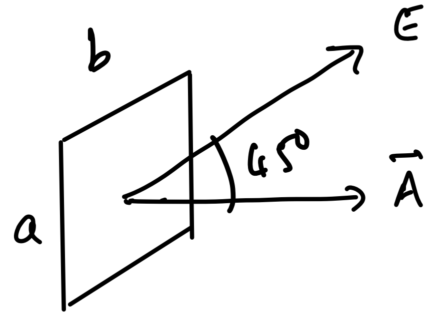
$$\phi = \vec{E}\cdot\vec{A}$$

$$= E \times A \times \cos 30^\circ$$

$$= E \times a^2 \times \frac{\sqrt{3}}{2}$$

$$\Rightarrow \boxed{\phi = \frac{\sqrt{3}\,E a^2}{2}}$$

(Q2)



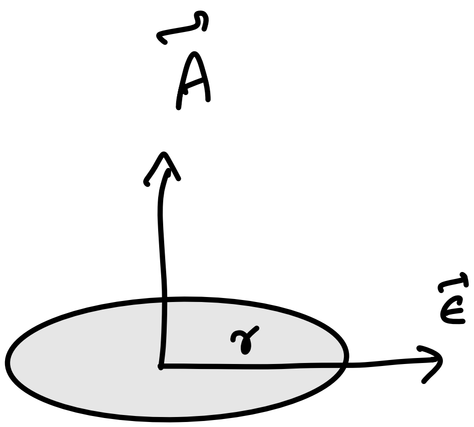
$$\phi = \vec{E} \cdot \vec{A}$$

$$= E \times ab \times \cos 45^\circ$$

$$= Eab * \frac{1}{\sqrt{2}}$$

$$\phi = \frac{\sqrt{2}\, Eab}{2}$$

(Q3)



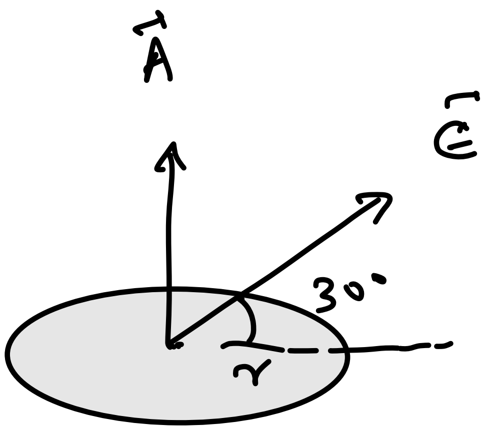
$$\phi = \vec{E} \cdot \vec{A}$$

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

$$= \vec{E} \times \pi r^2 \times \cos 90^\circ$$

$$\phi = 0$$

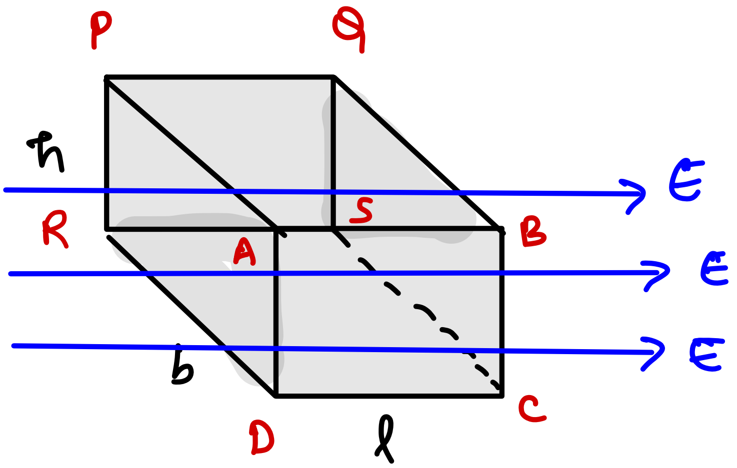
(Q4)

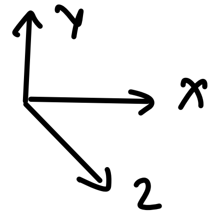


$$\phi = \vec{E} \cdot \vec{A}$$

$$= E \times \pi r^2 \times \cos 60^\circ$$

$$\phi = \frac{\pi E r^2}{2}$$





We have 6 surfaces. Let us find electric flux thro' each of them.

PQRS $(-\hat{k})$

$$\phi_1 = \vec{E} \cdot \vec{A} = E \times lh \times \cos 90^\circ = 0$$

ABCD $(\hat{k})$

$$\phi_2 = \vec{E} \cdot \vec{A} = E \times lh \times \cos 90^\circ = 0$$

PQ AB $(\hat{j})$

$$\phi_3 = \vec{E} \cdot \vec{A} = E \times lb \times \cos 90^\circ = 0$$

RS CD $(-\hat{j})$

$$\phi_4 = \vec{E} \cdot \vec{A} = E \times lb \times \cos 90^\circ = 0$$

BCSQ (+i)

$\phi_5 = \vec{E}\cdot\vec{A} = E \times bh \times \cos 0^\circ = \underline{\underline{Ebh}}$

PARD (−i)

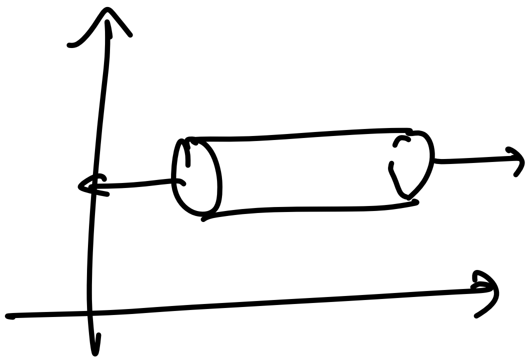
$\phi_6 = \vec{E}\cdot\vec{A} = E \times bh \times \cos 180^\circ = \underline{\underline{-Ebh}}$

Total flux = $0 + 0 + 0 + 0 + Ebh + (-Ebh)$

$= \underline{\underline{0}}$

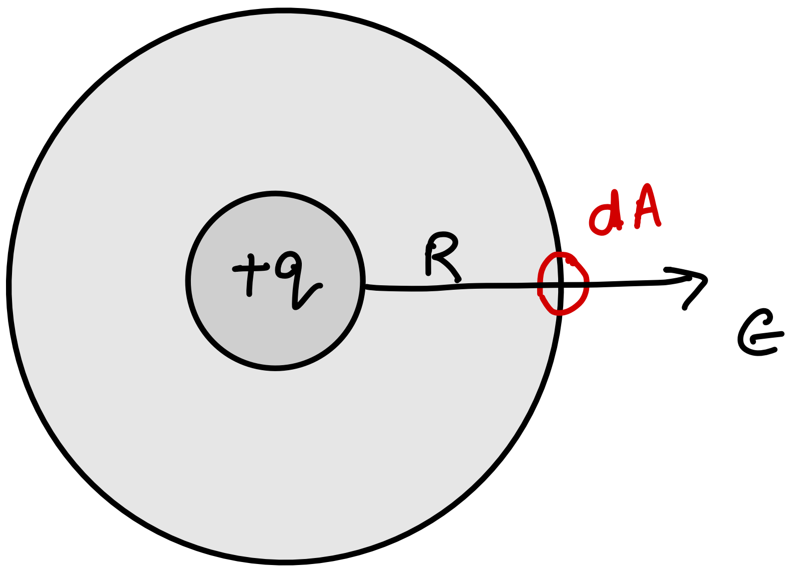
Total flux inside a closed surface w/o any charge is equal to zero.

If I am considering a cylinder,



Total flux = $\underline{\underline{0}}$ (radial direction)

Electric flux inside a sphere



$$E = \frac{1}{4\pi\varepsilon} \times \frac{q}{R^2}.$$

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

$$d\phi = \vec{E} \cdot \vec{dA}$$

$$= E \times dA \times \cos 0^\circ$$

$$= E \cdot dA$$

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

$$\Rightarrow \phi = \int E \, dA$$

$$\phi = E \times \int dA$$

$$= E \times 4\pi R^2$$

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

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

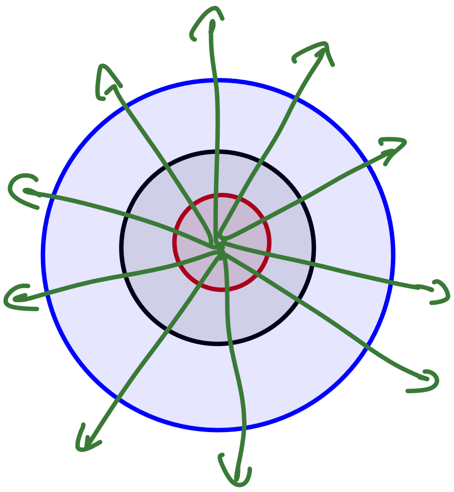
$\Rightarrow$

Gauss Law

Net electric field thro' a closed surface is $\frac{1}{\varepsilon_0}$ times the net charge enclosed by the surface.

$$\phi_{closed} = \frac{q_{net\ inside}}{\varepsilon_0} = \oint E\,dA$$

We derived this in last page



→ get the concept. The same flux passes thro' all spheres. So net electric flux does not depend on area.

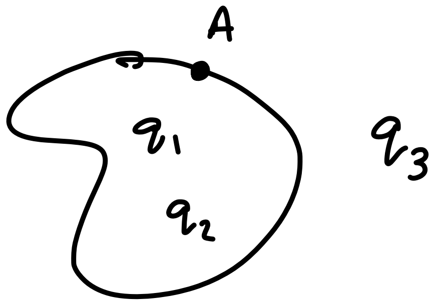
↓

even shape has no significance.

Important Points to note

1) The surface which encloses a charge, is called a gaussian surface.

2) Net flux through a surface due to an external surface is always equal to zero.



$E_A \rightarrow$ electric field at due to $q_1\ q_2\ q_3$.

$$\phi = \frac{q_1 + q_2}{\varepsilon_0}$$

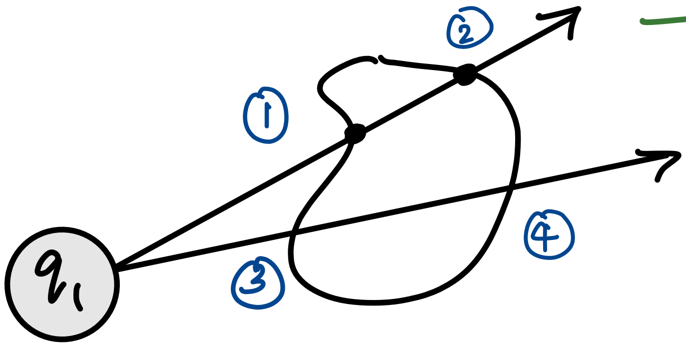
Flux due to $q_1\ q_2$

i.e.

$$\phi = \frac{q_1 + q_2}{\varepsilon_0} = \oint \vec{E}\, d\vec{A}$$

This $\vec{E}$ includes q_1, q_2, q_3

③ No net electric flux thro' a surface due to the presence of a charge outside the surface.



flux entering thro' 1 leaves thro' 2.
and entering thro' 3, leave thro 4.

$\phi_1 = E_1 \times dA \cos 180^\circ$

$\phi_2 = E_2\, dA \cos 0^\circ$

But $E_1 = E_2$

$\Rightarrow \phi_1 + \phi_2 = 0$

Gauss law is always applicable but not always useful.

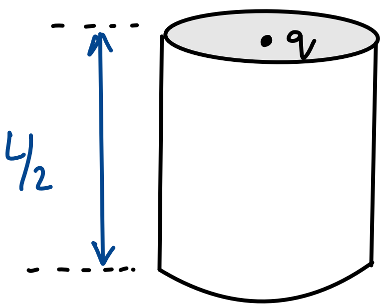
1) The gaussian surface should be symmetric about charge / charge distribution.

2) The $\vec{E}$ field must be symmetric (equal / constant) at all points of gaussian surface.

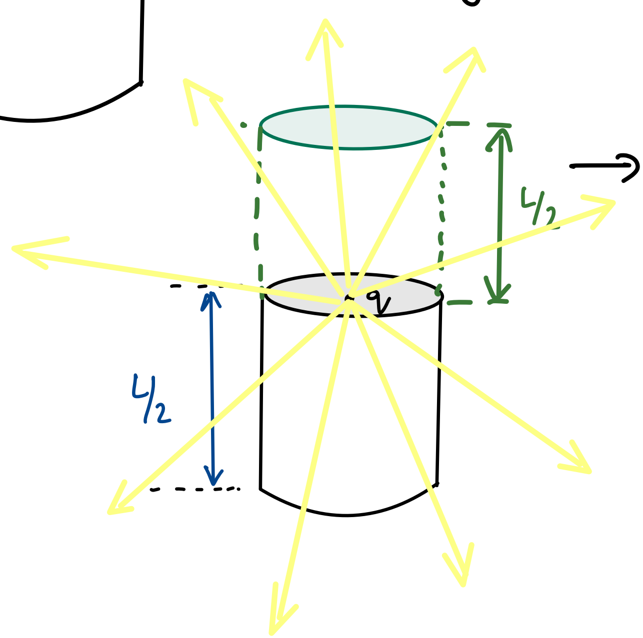
3) θ must be same at all points ($\vec{E}$ & $\vec{A}$) of the surface.

4) Gaussian surface must not pass thro' any point charge.

Q1



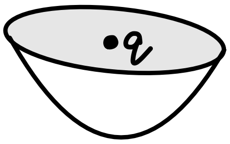
Find the value of flux from this cylinder.



→ flux thro' full cylinder is q/ε_0.

So half cylinder is $\dfrac{q}{2\varepsilon_0}$

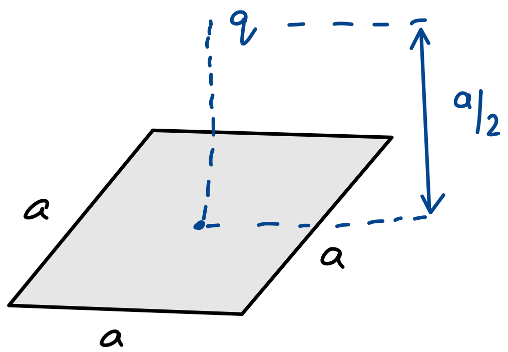
Q2 Find the value of flux thro' a hemi-sphere.



Through a sphere $\frac{q}{\varepsilon_0}$.

hemi-sphere $\frac{q}{2\varepsilon_0}$

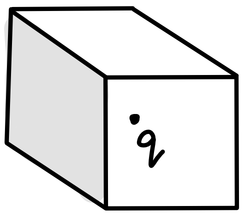
Q3 Find the electric flux due to q from this plate.



→ This could be inside a cube of side a. and charge at its centre.

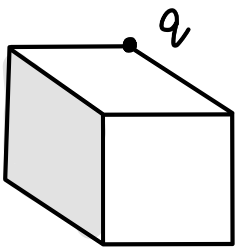
⇒ thro' the plate is $\frac{q}{6\varepsilon_0}$

Q4



Flux thro' shaded region when q is in middle → $\frac{q}{6\varepsilon_0}$.

Q5



→

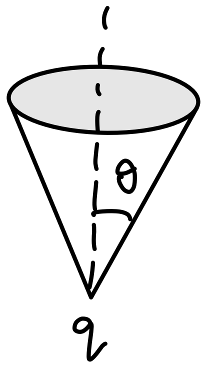
Flux thro' the cube

$\frac{q}{8\varepsilon_0}$ Complete cube such that q become at centre

Flux thro each face.

→ $\frac{q}{8\times3\varepsilon_0} = \frac{q}{24\varepsilon_0}$

Q6

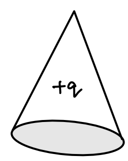


ϕ_{cone} is a part of sphere.

$$\phi_{cone} = \frac{q}{2\varepsilon_0}(1-\cos\theta)$$

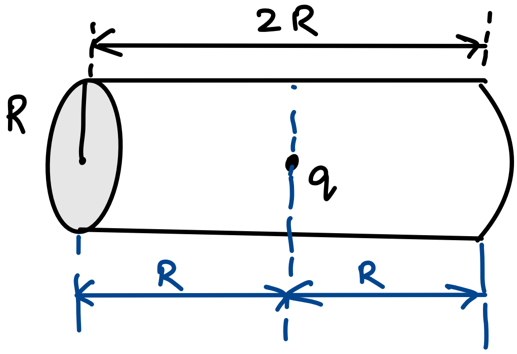
when charge is at vertex.

Q7

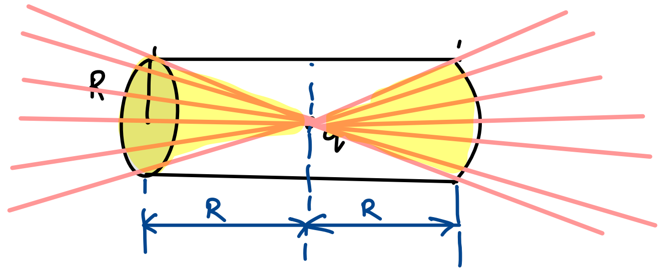


→ what is the value?

Q7



Find the electric flux due to q thro' CSA?



Thro' the shaded region is

$$\frac{q}{2\varepsilon_0}(1-\cos\theta)\times 2$$

$$\phi_{Total} = \frac{q}{\varepsilon_0}.$$

$$\frac{q}{\varepsilon_0}(1-\cos\theta)$$

$$\phi_{CSA} = \frac{q}{\varepsilon_0} - \frac{q}{\varepsilon_0}(1-\cos\theta)$$

$$= \frac{q}{\varepsilon_0}(1-1+\cos\theta) = \frac{q}{\varepsilon_0}\times\cos\theta \qquad \theta = 45^\circ$$

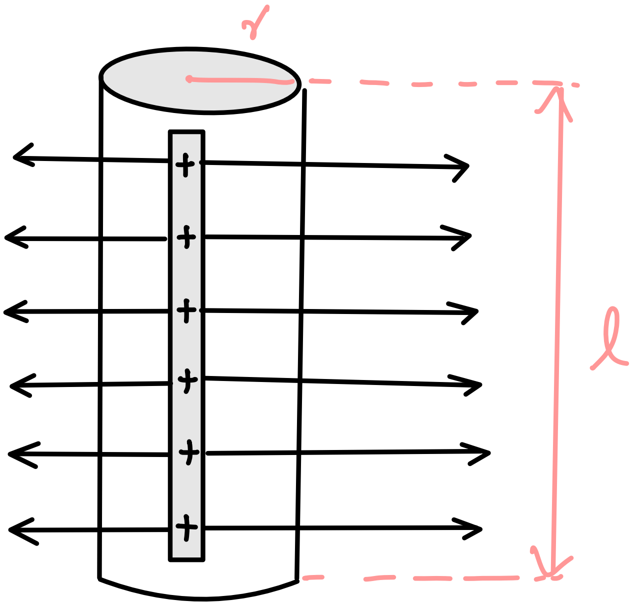
$$\Rightarrow \frac{q}{\sqrt{2}\,\varepsilon_0}$$

Application of gauss law

To find electric field due to a line charge

Consider an a line charge as shown in figure

$q = \lambda L$ $\quad \lambda \rightarrow$ charge per unit length.



Acc. to definition of electric flux,

$$\phi = E \times A$$

$$= E \times 2\pi r l \quad \text{——} \ (1)$$

(only CSA considered)

According to gauss law,

$$\phi = \frac{q}{\varepsilon_0} \quad \text{——} \ (2)$$

Comparing eq (1) and eq (2),

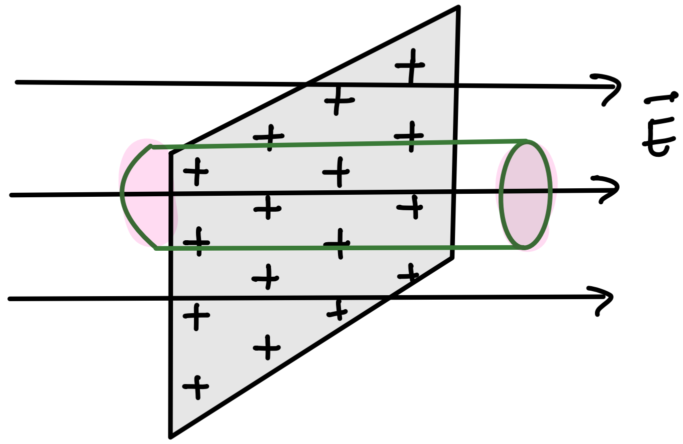
$$\frac{q}{\varepsilon_0} = E \times 2\pi r l \quad \Rightarrow$$

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

$$\frac{\lambda \cancel{l}}{\varepsilon_0} = E \times 2\pi r \cancel{l}$$ (by definition of λ)

To find electric field due to an infinite sheet of charge

Consider a sheet of charge as shown in figure.



$$q = \sigma \times A$$

σ - charge per unit area.

According to electric flux,

$$\phi = E \times A$$

$$= E \times 2A \quad \text{(A - area of circular portion)}$$

According to gauss law,

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

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

$$\frac{\sigma \times A}{\varepsilon_0} = E \times 2A \Rightarrow \boxed{E = \frac{\sigma}{2\varepsilon_0}}$$