



Padalsalai's Telegram Groups!

(தலைப்பிற்கு கீழே உள்ள லிங்கை கிளிக் செய்து குழுவில் இணையவும்!)

- Padalsalai's NEWS - Group
https://t.me/joinchat/NIfCqVRBNj9hhV4wu6_NqA
- Padalsalai's Channel - Group
<https://t.me/padasalaichannel>
- Lesson Plan - Group
<https://t.me/joinchat/NIfCqVWwo5iL-21gpzrXLw>
- 12th Standard - Group
https://t.me/Padalsalai_12th
- 11th Standard - Group
https://t.me/Padalsalai_11th
- 10th Standard - Group
https://t.me/Padalsalai_10th
- 9th Standard - Group
https://t.me/Padalsalai_9th
- 6th to 8th Standard - Group
https://t.me/Padalsalai_6to8
- 1st to 5th Standard - Group
https://t.me/Padalsalai_1to5
- TET - Group
https://t.me/Padalsalai_TET
- PGTRB - Group
https://t.me/Padalsalai_PGTRB
- TNPSC - Group
https://t.me/Padalsalai_TNPSC

① LESSON

Electrostatics

Electro
Electric charge

Static
stable

Electrostatics

Rest charge
(not moving
charge)

static charge
(moving charge)

Classification

Charge

⊕

Positive
charge (+q)

⊖

Negative
charge (-q)

characteristics

* Attraction (கவர்த்தல், ஈர்க்கல்)

* Repulsive (கிடைக்கல்)

Attraction

opposite charge

+q

-q

-q

+q

unlike charge

Repulsive

(same charge)

 $(+q)$ $(+q)$ $(-q)$ $(-q)$

like charge

Material

* Conductor

- allowed charge

* Semi Conductor

- மிதம்

* Insulator

- not allowed charge

Example for conductor

* Metals

* Human body

* Earth

Example for Insulator

* Plastic

* Glass

* Ebonite etc

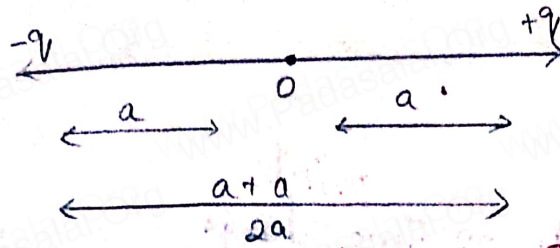
Ebonite

Example for Semiconductor

* Germanium (Ge)

* Silicon (Si)

Electric Dipole



Equal and opposite charge separated,
 very small distance ($2a$) is called
 electric dipole.

$2a \rightarrow$ very small distance

$-q \rightarrow$ Negative charge

$+q \rightarrow$ Positive charge

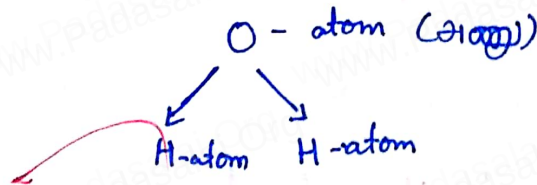
Example

H_2O

CO

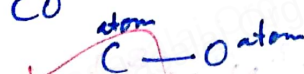
NH_3

H_2O - molecule



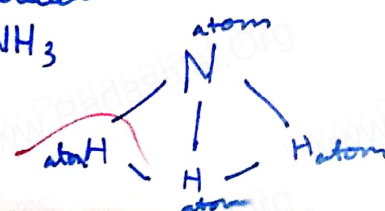
molecule

CO

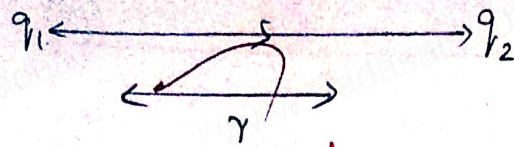


molecule

NH_3



Coulomb force.



$q_1, q_2 \rightarrow$ Two point charge

$r \rightarrow$ distance

$F \rightarrow$ force

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

Attraction (or) Repulsive two point charge

$$F \propto \frac{1}{r^2} (q_1, q_2)$$

Inverse (or) Square

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

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

$k =$ constant of proportionality

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

$\epsilon_0 =$ Permittivity of free space

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

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

Medium

$$\textcircled{F_m} = \frac{1}{4\pi\epsilon} \times \frac{q_1 q_2}{r^2} \rightarrow \textcircled{2}$$

ϵ = Permittivity of Medium.

divided by $\frac{\textcircled{1}}{\textcircled{2}}$

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

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

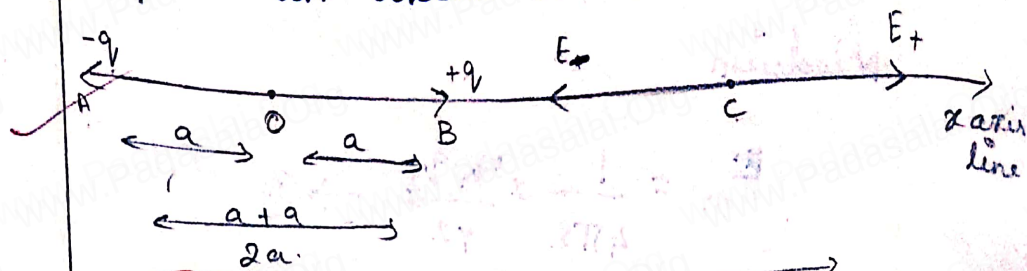
$$= \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2} \times \frac{4\pi\epsilon}{1} \times \frac{r^2}{q_1 q_2}$$

$$= \frac{1}{\epsilon_0} \times \epsilon$$

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

ϵ_r = Relative Permittivity

Electric field due to an electric dipole in axial line



AB = Two Point

$-q$ = Negative charge

$+q$ = Positive charge

a = Distance

$2a$ = Very small distance

E_+ E_- = Electric field

O = centre

OA = a

OB = a

AB = $2a$

r = distance

B is a point positive charge ($+q$) in Electric dipole

$$E_+ = \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r-a)^2}$$

A is a point negative charge ($-q$) in Electric dipole

$$E_- = \frac{1}{4\pi\epsilon_0} \times \left(\frac{q}{(r+a)^2} \right)$$

Total Electric field

$$E_{\text{total}} = E_+ + E_-$$

$$= \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r-a)^2} + \frac{1}{4\pi\epsilon_0} \times \frac{-q}{(r+a)^2}$$

$$= \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r-a)^2} - \frac{1}{4\pi\epsilon_0} \times \frac{q}{(r+a)^2}$$

$$= \frac{q}{4\pi\epsilon_0} \times \frac{1}{(r-a)^2} - \frac{q}{4\pi\epsilon_0} \times \frac{1}{(r+a)^2}$$

$$= \frac{q}{4\pi\epsilon_0} \left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2} \right]$$

$$= \frac{q}{4\pi\epsilon_0} \left[\frac{(r+a)^2 - (r-a)^2}{(r^2 - a^2)^2} \right]$$

$$= \frac{q}{4\pi\epsilon_0} \left[\frac{r^2 + a^2 + 2ra - (r^2 + a^2 - 2ra)}{(r^2 - a^2)^2} \right]$$

$$= \frac{q}{4\pi\epsilon_0} \left[\frac{r^2 + a^2 + 2ra - r^2 - a^2 + 2ra}{(r^2 - a^2)^2} \right]$$

$$E_{\text{total}} = \frac{q}{4\pi\epsilon_0} \left[\frac{4ra}{(r^2 - a^2)^2} \right]$$

$$r \gg a$$

a is neglected

(neglected)

$$= \frac{q}{4\pi\epsilon_0} \left[\frac{4ra}{(r^2)^2} \right]$$

$$= \frac{q}{4\pi\epsilon_0} \left[\frac{4ra}{r^4} \right]$$

$$= \frac{q}{4\pi\epsilon_0} \left[\frac{4a}{r^3} \right]$$

$$= \left[\frac{1}{4\pi\epsilon_0} \times \frac{q \times 4a}{r^3} \right]$$

$$\vec{p} = q \times 2a$$

$$2\vec{p} = q \times 4a$$

p = Electric dipole moment.

$$E_{\text{total}} = \left[\frac{1}{4\pi\epsilon_0} \times \frac{2\vec{p}}{r^3} \right]$$

1 Mark.

1. Coulomb force formula.

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

2. what is meant by Electrostatics
Rest charge and static charge

3. Different type of charge

two type

4. Conductor Example

Metals

5. Insulator Example
glass
6. Electric dipole Example
 H_2O
7. Electric dipole moment formula.
 $\vec{p} = q \times 2a$
8. Electric dipole — distance
Very small
9. ϵ_0 meant by ?
Permittivity of free space
10. ϵ_r meant by ?
relative permittivity.
11. ϵ meant by ?
Permittivity of medium.
12. Coulomb force directly proportional
to product of distance product of distance
13. Coulomb force inversely proportional
to square of distance square of distance
14. Semiconductor Example
Germanium (Ge), Silicon (Si)

15.

Equal and opposite charge separated
at very small distance is called
Electric dipole.

16.

charge — unit ?

Coulomb c.

AB → two Point

F → force

O → Centre

E → Electric field

a → distance

2a → Very Small distance

E_{total} → total Electric field

q → charge

-q → Negative charge

+q → Positive charge

k → constant Proportionality

ϵ → Permittivity of medium

ϵ_r → Relative Permittivity

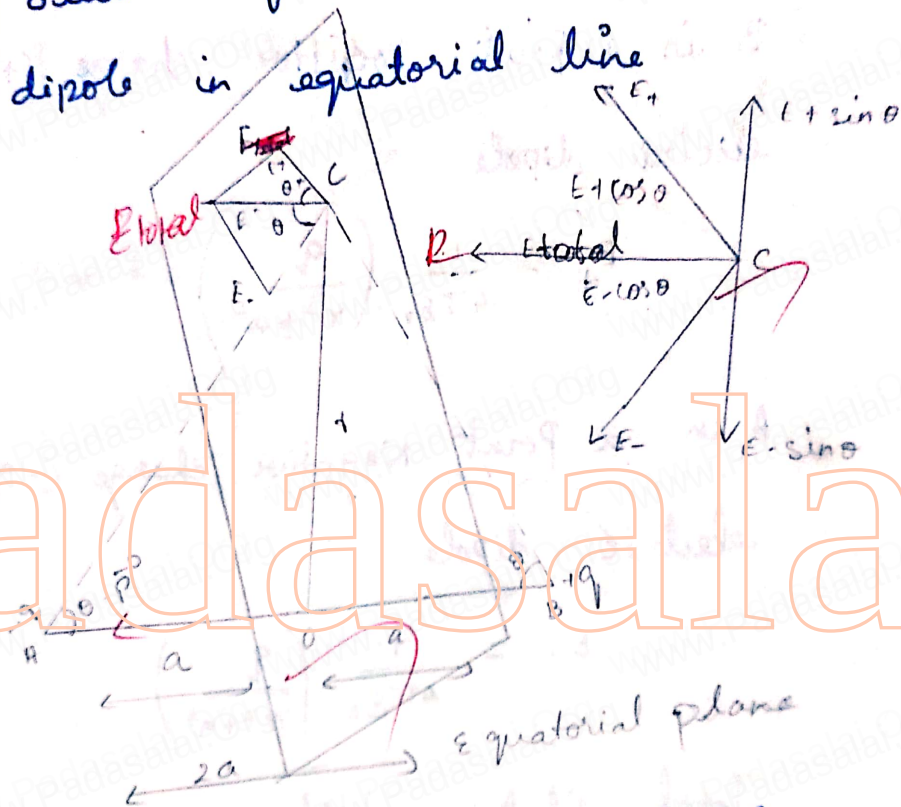
ϵ_0 → Permittivity of free space

Ge → Germanium

Si → Silicon.

5 mark

- ① Electric field due to an electric dipole in equatorial line



AB - Two Point

$2a$ - Very small distance

a - Distance

E_{total} - Total Electric field

$E_+ E_-$ - Electric field

O - Centre

P - Electric dipole moment

r - distance

θ - angle

$$\begin{aligned} OA &= a \\ OB &= a \\ AB &= 2a \\ OC &= r \end{aligned}$$

$E + \sin \theta$
 $E - \sin \theta$ } - opposite direction, (cancel each other)
 ↓
 Perpendicular component.

$E + \cos \theta$
 $E - \cos \theta$ } - same direction
 ↓
 Parallel component

B in a point positive charge (+q) in electric dipole

$$E_+ = \frac{1}{4\pi\epsilon_0} \left(\frac{q}{r^2 + a^2} \right)$$

A in a point negative charge (-q) in electric dipole

$$E_- = \frac{1}{4\pi\epsilon_0} \left(\frac{q}{r^2 + a^2} \right)$$

Total Electric field (same direction)

$$E_{\text{total}} = -2E \cos \theta$$

$$E_{\text{total}} = -2 \left(\frac{1}{4\pi\epsilon_0} \frac{q}{r^2 + a^2} \right) \times \cos \theta$$

$$E_{\text{total}} = -2 \left(\frac{1}{4\pi\epsilon_0} \frac{q}{r^2 + a^2} \right) \times \frac{a}{\sqrt{r^2 + a^2}}$$

$$E_{\text{total}} = -2 \left(\frac{1}{4\pi\epsilon_0} \frac{q}{r^2 + a^2} \right) \times \frac{a}{(r^2 + a^2)^{3/2}}$$

$$E_{total} = \frac{-2q}{4\pi\epsilon_0} \frac{1}{(r^2+a^2)} \times \frac{a}{(r^2+a^2)^{1/2}}$$

$$E_{total} = \frac{-2qa}{4\pi\epsilon_0} \frac{1}{(r^2+a^2)} \times \frac{1}{(r^2+a^2)^{1/2}}$$

$$\vec{P} = q \times 2a \text{ (Electric dipole moment)}$$

$$E_{total} = \frac{-\vec{P}}{4\pi\epsilon_0} \frac{1}{(r^2+a^2)(r^2+a^2)^{1/2}}$$

$$E_{total} = \frac{-\vec{P}}{4\pi\epsilon_0} \frac{1}{(r^2+a^2)^{3/2}}$$

$$E_{total} = \frac{-\vec{P}}{4\pi\epsilon_0} \frac{1}{(r^2+a^2)^{3/2}}$$

($r \gg a$) a is neglected

$$E_{total} = \frac{-\vec{P}}{4\pi\epsilon_0} \frac{1}{(r^2)^{3/2}}$$

$$= \frac{-\vec{P}}{4\pi\epsilon_0} \frac{1}{r^3}$$

$$E_{total} = -\frac{1}{4\pi\epsilon_0} \cdot \frac{\vec{P}}{r^3} //$$

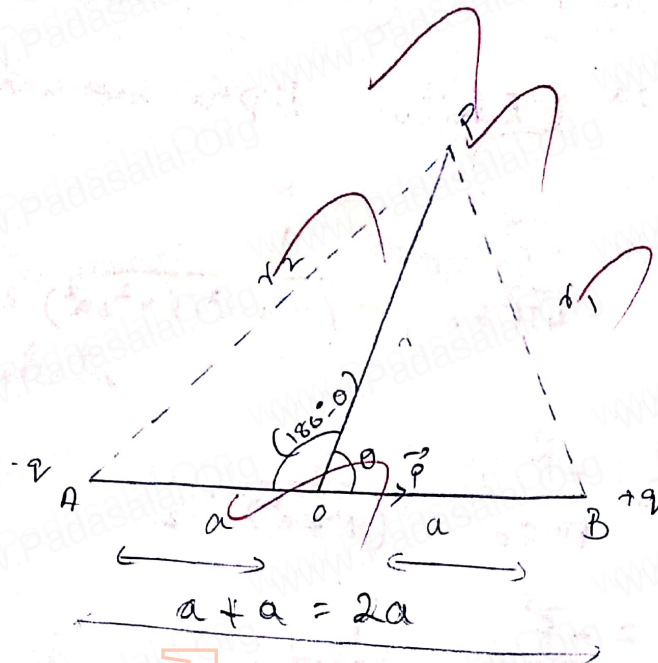
Electrostatic Potential due to an

(H)

electric dipole &

☼

Potential - unit (volt) (V)



AB = two point

 θ = angle $2a$ = very small distance a = distance r = distance $-q$ = negative charge $+q$ = positive charge.

O = centre

 P = Electric dipole momentAB = $2a$ OA = a OB = a BP = r_1 AP = r_2

BoP = Triangle (r_1)

AOP = Triangle (r_2)

BoP in a Point Positive charge (+q) in electric potential

$$V_1 = \frac{1}{4\pi\epsilon_0} \frac{q}{r_1}$$

A in a Point Negative charge (-q) in electric potential

$$V_2 = \frac{1}{4\pi\epsilon_0} \left(\frac{-q}{r_2} \right)$$

Total Electric Potential

$$V = V_1 + V_2$$

$$V = \left[\left(\frac{1}{4\pi\epsilon_0} \frac{q}{r_1} \right) + \left(\frac{1}{4\pi\epsilon_0} \left(\frac{-q}{r_2} \right) \right) \right]$$

$$V = \left[\left(\frac{1}{4\pi\epsilon_0} \frac{q}{r_1} \right) - \left(\frac{1}{4\pi\epsilon_0} \frac{q}{r_2} \right) \right]$$

$$V = \left[\frac{q}{4\pi\epsilon_0} \frac{1}{r_1} - \frac{q}{4\pi\epsilon_0} \frac{1}{r_2} \right]$$

$$V = \frac{q}{4\pi\epsilon_0} \left[\frac{1}{r_1} - \frac{1}{r_2} \right]$$

To find $\frac{1}{r_1}$ values

BOP Triangle

Applying cosine law

$$r_1^2 = r^2 + a^2 - 2ra \cos \theta$$

$$r_1^2 = r^2 \left(1 + \frac{a^2}{r^2} - \frac{2a}{r} \cos \theta \right)$$

$$r_1^2 = r^2 \left(1 - \frac{2a}{r} \cos \theta \right)$$

$\frac{a^2}{r^2}$ is neglected

$$r_1^2 = r^2 \left(1 - 2a \frac{\cos \theta}{r} \right)$$

$$r_1 = r \left(1 - 2a \frac{\cos \theta}{r} \right)^{1/2}$$

Invert

$$\frac{1}{r_1} = \frac{1}{r} \frac{1}{\left(1 - 2a \frac{\cos \theta}{r} \right)^{1/2}}$$

$$= \frac{1}{r} \left(1 + 2a \frac{\cos \theta}{r} \right)^{1/2}$$

$$\frac{1}{r_1} = \frac{1}{r} \left(1 + a \frac{\cos \theta}{r} \right)$$

To find $\frac{1}{r_2}$ values.

AOP Triangle

cosine law

$$r_2^2 = r^2 + a^2 - 2ra \cos(180^\circ - \theta)$$

$$\cos(180^\circ - \theta) = -\cos \theta$$

$$r_2^2 = r^2 + a^2 - 2ra(-\cos \theta)$$

$$= r^2 + a^2 + 2ra \cos \theta$$

$$= r^2 \left(1 + \frac{a^2}{r^2} + \frac{2a}{r} \cos \theta \right)$$

$\frac{a^2}{r^2}$ is neglected.

$$r_2^2 = r^2 \left(1 + \frac{2a}{r} \cos \theta \right)$$

$$r_2 = r \left(1 + 2a \frac{\cos \theta}{r} \right)^{\frac{1}{2}}$$

Inverse

$$\frac{1}{r_2} = \frac{1}{r} \left(\frac{1}{\left(1 + 2a \frac{\cos \theta}{r} \right)^{\frac{1}{2}}} \right)$$

$$= \frac{1}{r} \left(1 + 2a \frac{\cos \theta}{r} \right)^{-\frac{1}{2}}$$

$$\frac{1}{r_2} = \frac{1}{r} \left(1 - \frac{a \cos \theta}{r} \right)$$

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Total electric potential

$$V = \frac{q}{4\pi\epsilon_0} \left[\frac{1}{r_1} - \frac{1}{r_2} \right]$$

$$= \frac{q}{4\pi\epsilon_0} \left[\frac{1}{r} \left(1 + \frac{a \cos \theta}{r} \right) - \frac{1}{r} \left(1 - \frac{a \cos \theta}{r} \right) \right]$$

$$= \frac{q}{4\pi\epsilon_0} \frac{1}{r} \left[\left(1 + \frac{a \cos \theta}{r} \right) - \left(1 - \frac{a \cos \theta}{r} \right) \right]$$

$$= \frac{q}{4\pi\epsilon_0} \frac{1}{r} \left[\frac{1 + a \cos \theta}{r} - \frac{1 - a \cos \theta}{r} \right]$$

$$= \frac{q}{4\pi\epsilon_0} \frac{1}{r} \left[\frac{a \cos \theta}{r} + \frac{a \cos \theta}{r} \right]$$

$$= \frac{q}{4\pi\epsilon_0} \frac{1}{r} \left[a + a \left(\frac{\cos \theta}{r} \right) \right]$$

$$= \frac{q \times 2a \cos \theta}{4\pi\epsilon_0 r \times r}$$

$$= \frac{q}{4\pi\epsilon_0} \frac{1}{r} \left[\frac{2a \cos \theta}{r} \right]$$

$$= \frac{q \times 2a \cos \theta}{4\pi\epsilon_0 r \times r}$$

$$\vec{\Phi} = q \times 2a$$

$$V = \frac{\vec{\Phi} \cdot \cos \theta}{4\pi\epsilon_0 r^2}$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{P \cos \theta}{r^2}$$

Special case

i) $+q$ (Positive charge)

Axial line

$$\theta = 0^\circ$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{P \cdot \cos \theta}{r^2}$$

$$= \frac{1}{4\pi\epsilon_0} \frac{P \cdot \cos(0^\circ)}{r^2}$$

$$\cos(0^\circ) = 1$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{P(1)}{r^2}$$

$$V = \frac{P}{4\pi\epsilon_0 r^2}$$

ii) $-q$ (Negative charge)

Axial line

$$\theta = 180^\circ$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{P \cdot \cos \theta}{r^2}$$

$$\cos 180^\circ = -1$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{P \cos(180^\circ)}{r^2}$$

$$= \frac{1}{4\pi\epsilon_0} \frac{P(-1)}{r^2}$$

$$V = \frac{-P}{4\pi\epsilon_0 r^2}$$

iii) Equatorial line

$$\theta = 90^\circ$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{P \cos \theta}{r^2}$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{P \cos(90^\circ)}{r^2}$$

$$\cos 90^\circ = 0$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{P(0)}{r^2}$$

$$V = \frac{1}{4\pi\epsilon_0} 0$$

$$V = 0$$

Electric flux (ϕ_E) 

Electric flux $\rightarrow$ electric charge
flux $\rightarrow$ $\perp$ to ω to

$$\phi_E = \oint E \, dA \cos \theta$$

$A \rightarrow$ cross sectional area

Area $\Rightarrow$ length $\times$ breadth.

$E \rightarrow$ Electric field

$\phi_E \rightarrow$ electric flux

$\theta \rightarrow$ angle.



$$\phi_E = \oint E \, dA \cos \theta$$

$\oint \rightarrow$ closed Integral

closed surface
(ω to ω)

$$\phi_E = \oint E \, dA \cos \theta$$

$$\phi_E = EA \cos \theta$$

$$\theta = 0^\circ$$

$$\phi_E = EA \cos(0^\circ)$$

$$\cos(0^\circ) = 1$$

$$\phi_E = EA(1)$$

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

Gauss's law

Electric flux (Φ_E)

$$\Phi_E = \oint E \cdot dA \cos \theta$$

$$\Phi_E = E \oint dA \cos \theta$$

$$\theta = 0^\circ$$

$$\Phi_E = E \oint dA \cos(0^\circ)$$

$$\Phi_E = E \oint dA (1)$$

$$(\cos 0^\circ) = 1$$

$$\Phi_E = E \oint dA$$

$$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$$

Q = charge

Q = magnitude of charge

length or quantity of charge.

$$\oint dA = 4\pi r^2$$

$$\Phi_E = E \oint dA$$

$$= \frac{1}{4\pi\epsilon_0} \times \frac{Q}{r^2} \times 4\pi r^2$$

$$\Phi_E = \frac{Q}{\epsilon_0}$$

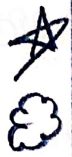
Φ_E = Electric flux

Q = Magnitude of charge

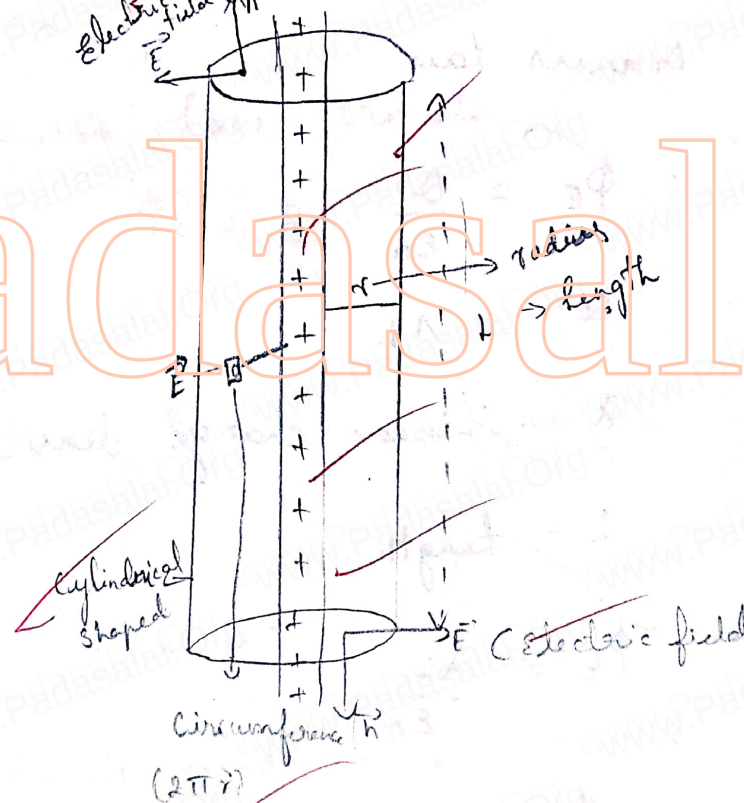
$\epsilon_0 \Rightarrow$ Permittivity of free space

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

Gauss's Law first Application.



is Electric field due to an infinitely
charged wire.



Electric flux

$$\Phi_E = \oint E dA \cos \theta$$

$$\theta = 0^\circ$$

$$\Phi_E = \oint E dA \cos(0^\circ)$$

$$\cos(0^\circ) = 1$$

$$\phi_E = \oint E \cdot dA \quad (1)$$

$$\phi_E = \oint E \, dA$$

$$\phi_E = E \oint dA$$

$$\oint dA = 2\pi r \cdot L$$

$$\phi_E = E \oint dA$$

$$\phi_E = E \cdot (2\pi r L) \rightarrow (1)$$

Gauss's law

$$\phi_E = \frac{Q}{\epsilon_0}$$

$$Q = \lambda \cdot L$$

λ = linear charge density

L = length.

$$\phi_E = \frac{\lambda L}{\epsilon_0}$$

$$\phi_E = \frac{Q}{\epsilon_0}$$

$$E (2\pi r L) = \frac{\lambda L}{\epsilon_0}$$

$$E = \frac{\lambda}{2\pi r \epsilon_0}$$

Vector form

$$\vec{E} = \frac{\lambda}{2\pi r \epsilon_0} \hat{r}$$

Two condition.

i) $\lambda > 0 \Rightarrow \vec{E}$ (Electric field)
Perpendicular outwards ($\hat{r}$).

ii) $\lambda < 0 \Rightarrow \vec{E}$ (Electric field)
Perpendicular inwards ($-\hat{r}$)

Mark.

1. Gauss's law formula

$$\phi_E = \frac{Q}{\epsilon_0}$$

2. ϵ_0 value

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ N}^{-1} \text{ m}^{-2}$$

3. ϵ_0 unit

$$\text{C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

4. Electric field flux symbol

$$\phi_E$$

5. Electric flux formula

$$\phi_E = \oint E \cdot dA \cos \theta$$

6. Electric flux — Quantity
Scalar

Electric flux — unit

$$Nm^2c^{-1}$$

8.

Electric potential unit —
volt

9.

Electric Potential due to an electric dipole formula —

$$V = \frac{1}{4\pi\epsilon_0} \frac{P \cos \theta}{r^2}$$

10.

Gauss's law based on the electric field due to an infinitely charged wire in condition $\lambda > 0$ is — ?

E (Electric field) Perpendicular outward

11.

Scalar

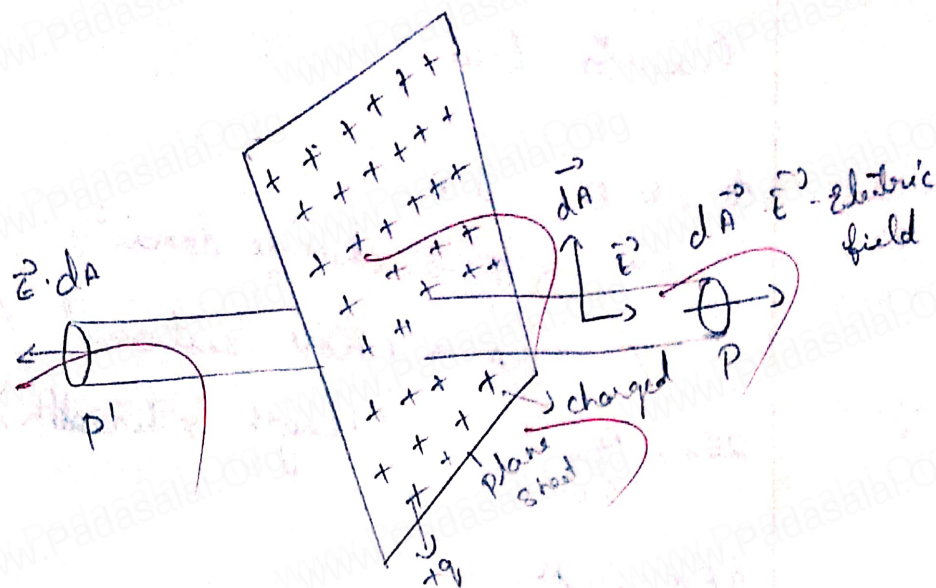
only magnitude

12.

Vector

both magnitude and direction

Gauss's Law second Application
Electric field due to an infinitely charged plane sheet



Electric flux

$$\Phi_E = \oint E \cdot dA \cos \theta$$

$$\theta = 0^\circ$$

$$\Phi_E = \oint E \cdot dA \cos(0^\circ)$$

$$\cos(0^\circ) = 1$$

$$\Phi_E = \oint E dA$$

$$\Phi_E = \oint E dA$$

$$\Phi_E = [\oint E dA]_P + [\oint E dA]_{P'}$$

$$\Phi_E = E [\oint dA]_P + E [\oint dA]_{P'}$$

$$\Phi_E = EA + EA$$

$$\Phi_E = 2EA \rightarrow \textcircled{1}$$

Gauss's law.

$$\Phi_E = \frac{Q}{\epsilon_0} \quad Q = \sigma A$$

$\sigma \rightarrow$ charge density

$A \rightarrow$ cross sectional Area.

$$2EA = \frac{Q}{\epsilon_0} \quad (\text{Length} \times \text{breadth})$$

$$2EA = \frac{\sigma A}{\epsilon_0}$$

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

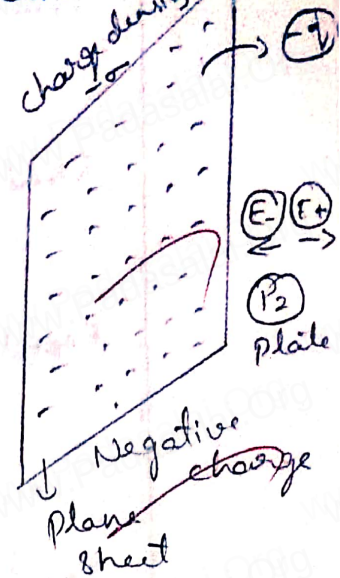
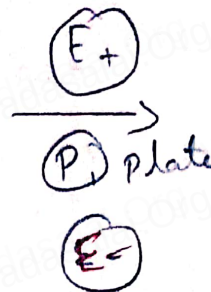
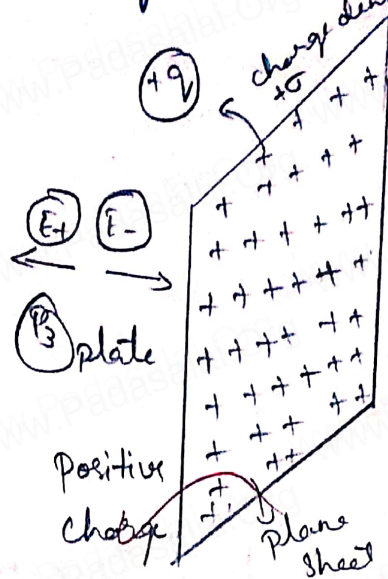
$$E = \frac{\sigma}{2\epsilon_0}$$

Condition.

$\sigma > 0$ Electric field perpendicular
Outward ($\hat{r}$)

$\sigma < 0$ Electric field perpendicular
Inwards ($-\hat{r}$).

Electric field due to an infinitely charged Two parallel plane sheet.



Same direction

Electric field

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

$$E_{total} = E_+ + E_-$$

$$E_{total} = \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0}$$

$$E_{total} = \frac{\sigma + \sigma}{2\epsilon_0}$$

$$E_{total} = \frac{2\sigma}{2\epsilon_0}$$

$$E_{total} = \frac{\sigma}{\epsilon_0}$$

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

$$\text{Volume} = \text{Area} \times \text{height} \\ = \text{length} \times \text{breadth} \times \text{height}$$

$$\text{Density} = \frac{\text{mass}}{\text{length} \times \text{breadth} \times \text{height}}$$

Opposite direction

$$E_{\text{total}} = E_+ - E_-$$

$$E_{\text{total}} = \frac{\sigma}{2\epsilon_0} - \frac{\sigma}{2\epsilon_0}$$

$$E_{\text{total}} = \frac{\sigma - \sigma}{2\epsilon_0}$$

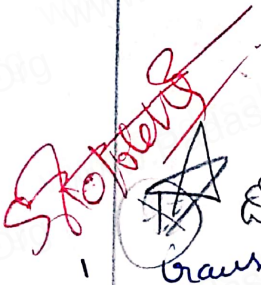
$$E_{\text{total}} = \frac{0}{2\epsilon_0}$$

$$E_{\text{total}} = 0$$

Condition.

$\sigma > 0$ Electric field Perpendicular outward ($\hat{r}$)

$\sigma < 0$ Electric field Perpendicular inward ($-\hat{r}$)



Gauss's law forth Application

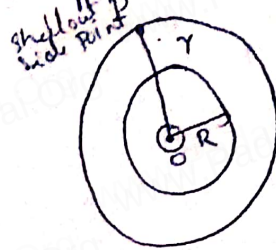
Electric field due to an charge
uniform spherical shell

i) At a point outside shell ($r > R$)

ii) At a surface point ($r = R$)

iii) At a point Inside shell ($r < R$)

i) At a point out side shell



Electric flux

$$\Phi_E = \oint E \, dA \cos \theta$$

$$\theta = 0^\circ$$

$$\Phi_E = \oint E \, dA \cos(0^\circ)$$

$$\cos 0^\circ = 1$$

$$\Phi_E = \oint E \cdot dA (1)$$

$$\Phi_E = E \oint dA$$

$$\oint dA = 4\pi r^2$$

$$\Phi_E = E (4\pi r^2)$$

ii) ~~At a surface point ($r = R$)~~

~~Gauss's law~~

$$\Phi_E = \frac{Q}{\epsilon_0}$$

$$\Phi_E = \frac{Q}{\epsilon_0}$$

$$E (4\pi r^2) = \frac{Q}{\epsilon_0}$$

$$E = \frac{Q}{4\pi r^2 \epsilon_0}$$

$$E = \frac{Q}{r^2} \times \frac{1}{4\pi\epsilon_0}$$

Vector form.

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \cdot \hat{r}$$

ii) At a surface point

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$$

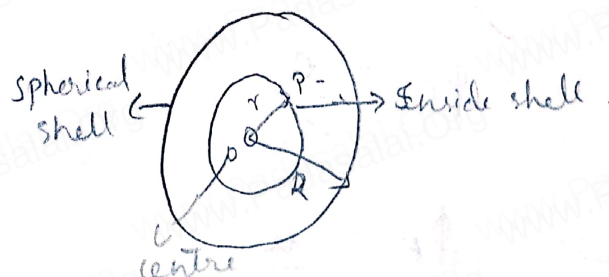
$r = R$

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \times \frac{Q}{R^2}$$

Vector form

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \times \frac{Q}{R^2} \cdot \hat{r}$$

iii) At a point inside shell.



Electric flux

$$\phi_E = \oint E \, dA \cos \theta$$

$$\theta = 0^\circ$$

$$\phi_E = \oint E \, dA \cos(\theta)$$

$$\cos(0) = 1$$

$$\phi_E = \oint E \, dA (1)$$

$$\phi_E = \oint E \, dA$$

$$\phi_E = E \oint dA$$

$$\oint dA = 4\pi r^2$$

$$\phi_E = E \cdot (4\pi r^2)$$

Gauss's law.

$$\phi_E = \frac{Q}{\epsilon_0}$$

$$E \cdot (4\pi r^2) = \frac{Q}{\epsilon_0}$$

$$E = \frac{Q}{4\pi \epsilon_0 r^2}$$

$$E = \frac{1}{4\pi \epsilon_0} \frac{Q}{r^2}$$

Charge No

$$Q = 0$$

$$E = \frac{1}{4\pi \epsilon_0} \cdot \frac{(0)}{r^2}$$

$$E = \frac{1}{4\pi\epsilon_0} (0)$$

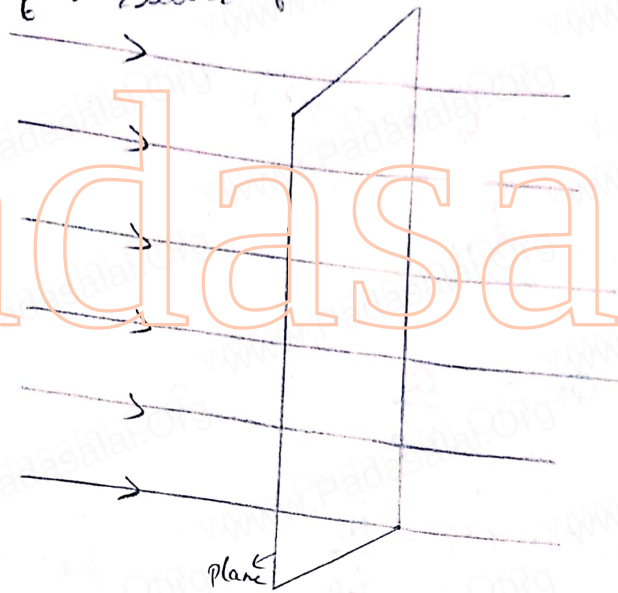
$$E = 0$$

Therefore electric field inside shell zero.

Electric flux conditions.

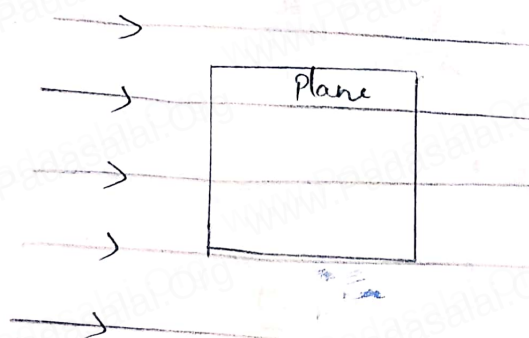
Three conditions.

$\vec{E} \rightarrow$ electric field

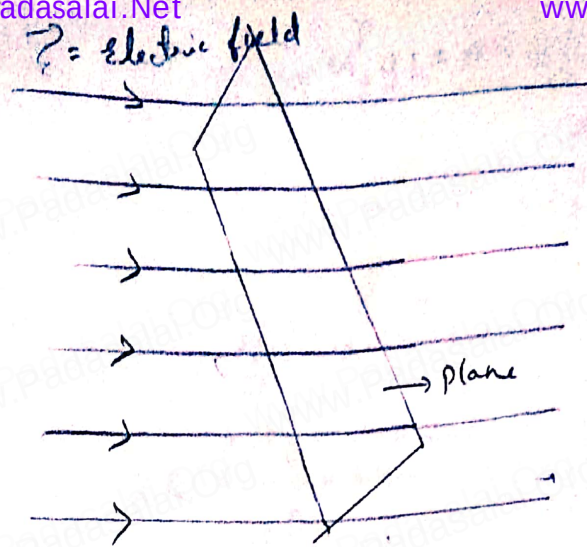


$$\phi = EA$$

$\vec{E} \rightarrow$ electric field



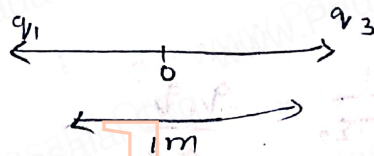
$$\phi_{E_{in}} = 0$$



$$\Phi E = EA (\cos \theta).$$

One Coulomb values $\therefore 9 \times 10^9 \text{ N}$.

charge unit



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

$$q_1 = 1 \text{ C}$$

$$q_2 = 1 \text{ C}$$

$$r = 1 \text{ m}$$

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

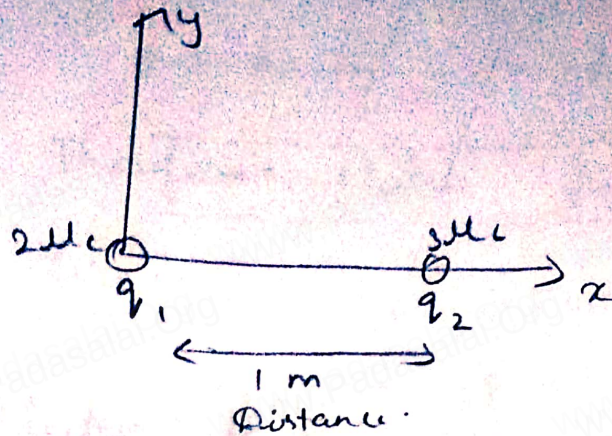
$$F = \frac{1}{4 \times 3.14 \times 8.854 \times 10^{-12}} \times \frac{1 \times 1}{(1)^2}$$

$$F = \frac{1}{4 \times 3.14 \times 8.854 \times 10^{-12}} \times \frac{1}{1}$$

$$F = \frac{10^{12}}{4 \times 3.14 \times 8.854} \times (1)$$

$$F = 9 \times 10^9 \text{ N}$$

mark.



$q_1 = +2 \mu\text{C}$ and $q_2 = +3 \mu\text{C}$
to find force values

$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2}$$

$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2} \rightarrow \text{charge}$$

$r^2 \rightarrow \text{distance}$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N}$$

$$\vec{F}_{12} = (9 \times 10^9) \times \frac{q_1 q_2}{r^2}$$

$$\vec{F}_{12} = (9 \times 10^9) \times \frac{2 \times 10^{-6} \times 3 \times 10^{-6}}{(1)^2}$$

$$r = 1 \text{ m}$$

$$+2 \mu\text{C} = 2 \times 10^{-6} \text{ C}$$

$$3 \mu\text{C} = 3 \times 10^{-6} \text{ C}$$

$\mu = \text{micro} \rightarrow 10^{-6}$
 $p = \text{pico} \rightarrow 10^{-12}$
 $n = \text{nano} \rightarrow 10^{-9}$

$$\begin{aligned}
 \vec{F}_{12} &= 9 \times 10^9 \times 2 \times 10^{-6} \times 3 \times 10^{-6} \\
 &= 9 \times 2 \times 3 \times 10^9 \times 10^{-6} \times 10^{-6} \\
 &= 54 \times 10^9 \times 10^{-12} \\
 &= 54 \times 10^{9-12} \\
 &= 54 \times 10^{-3}
 \end{aligned}$$

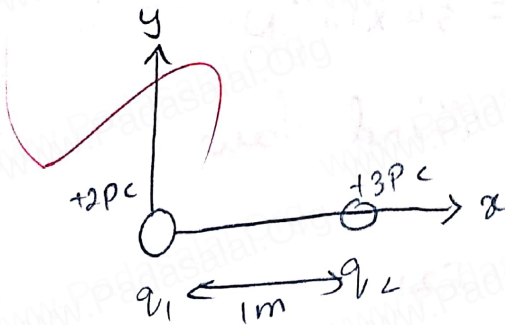
$$\vec{F}_{12} = 54 \times 10^{-3} \text{ N}$$

Newton third law.

$$\vec{F}_{12} = -\vec{F}_{21}$$

$$\vec{F}_{21} = -54 \times 10^{-3} \text{ N.}$$

1. charge configurations to find force values?



Force

$$F_{12} = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N}$$

$$q_1 = +2 \text{ pC} = +2 \times 10^{-12} \text{ C}$$

$$q_2 = +3 \text{ pC} = +3 \times 10^{-12} \text{ C}$$

$$r = 1 \text{ m}$$

$$F_{12} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r^2}$$

$$F_{12} = 9 \times 10^9 \times \left(\frac{2 \times 10^{-12} \times 3 \times 10^{-12}}{(1)^2} \right)$$

$$F_{12} = \frac{9 \times 10^9 \times 6 \times 10^{-24}}{1}$$

$$F_{12} = 54 \times 10^9 \times 10^{-24}$$

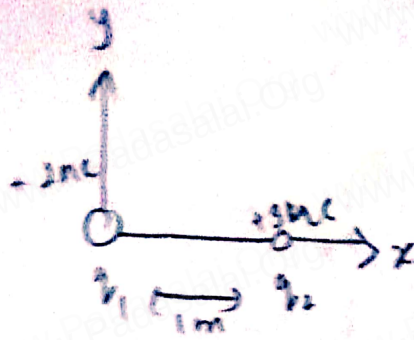
$$F_{12} = 54 \times 10^{-15}$$

$$F_{12} = 54 \times 10^{-15} \text{ N}$$

Newton Third law

$$F_{12} = -F_{21}$$

$$F_{21} = 54 \times 10^{-15} \text{ N}$$



Q. solution.

$$n \rightarrow \text{nano} - 10^{-9}$$

$$F_{12} = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N}$$

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

$$+3 \text{ nC} = +3 \times 10^{-9} \text{ C}$$

$$F_{12} = 9 \times 10^9 \left(\frac{2 \times 10^{-9} \times 3 \times 10^{-9}}{(1)^2} \right)$$

$$r = 1$$

$$F_{12} = 9 \times 10^9 \left(\frac{6 \times 10^{-9} \times 10^{-9}}{1} \right)$$

$$= 9 \times 10^9 \times 6 \times 10^{-9} \times 10^{-9}$$

$$= 9 \times 6 \times 10^9 \times 10^{-18}$$

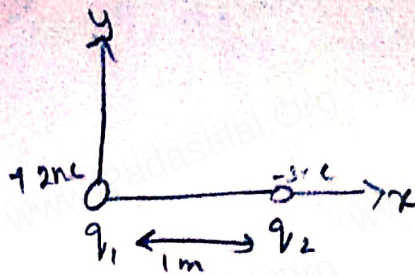
$$F_{12} = 54 \times 10^{-9} \text{ N}$$

Newton's third law

$$\vec{F}_{12} = -\vec{F}_{21}$$

$$F_{21} = -54 \times 10^{-9} \text{ N}$$

3.



Solution

$$F_{12} = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N}$$

$$q_1 = +2 \text{ nC}$$

$$q_2 = -3 \text{ nC}$$

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

$$-3 \text{ nC} = -3 \times 10^{-9} \text{ C}$$

$$r = 1$$

$$F_{12} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$

$$F_{12} = 9 \times 10^9 \times \left(\frac{2 \times 10^{-9} \times (-3) \times 10^{-9}}{(1)^2} \right)$$

$$= 9 \times 10^9 \times (-6 \times 10^{-9} \times 10^{-9})$$

$$= -54 \times 10^9 \times 10^{-9} \times 10^{-9}$$

$$= -54 \times 10^9 \times 10^{-18}$$

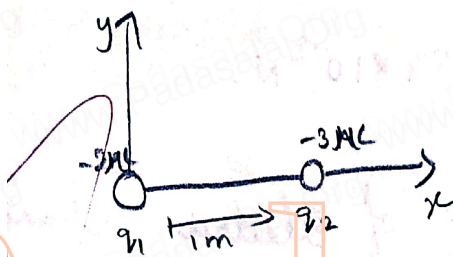
$$F_{12} = -54 \times 10^{-9} \text{ N}$$

$$F_{12} = -54 \times 10^{-9}$$

Newton's Third Law

$$F_{21} = -(-54 \times 10^{-9})$$

$$F_{21} = 54 \times 10^{-9}$$



Solution

$$F_{12} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r^2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N}$$

$$q_1 = -2 \mu\text{C} = -2 \times 10^{-6} \text{ C}$$

$$q_2 = -3 \mu\text{C} = -3 \times 10^{-6} \text{ C}$$

$$F_{12} = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2}$$

$$F_{12} = 9 \times 10^9 \frac{(-2 \times 10^{-6}) \times (-3 \times 10^{-6})}{(1)^2}$$

$$F_{12} = 9 \times 10^9 (6 \times 10^{-6} \times 10^{-6})$$

$$F_{12} = 9 \times 10^9 \times 6 \times 10^{-12}$$

$$F_{12} = 54 \times 10^{-3}$$

$$F_{12} = 54 \times 10^{-3}$$

Newton's Third Law

$$\vec{F}_{12} = -\vec{F}_{21}$$

$$\vec{F}_{21} = -54 \times 10^{-3} \text{ N.}$$

Quantisation of Electric charge.

$$q = ne$$

q = charge

n = Integer

e = Electronic charge or electron charge.

~~Electron~~ $\rightarrow$ Negative charge $= -1.6 \times 10^{-19} \text{ C}$

Proton $\rightarrow$ positive charge $= +1.6 \times 10^{-19} \text{ C}$

Neutron $\rightarrow$ No charge = Neutral

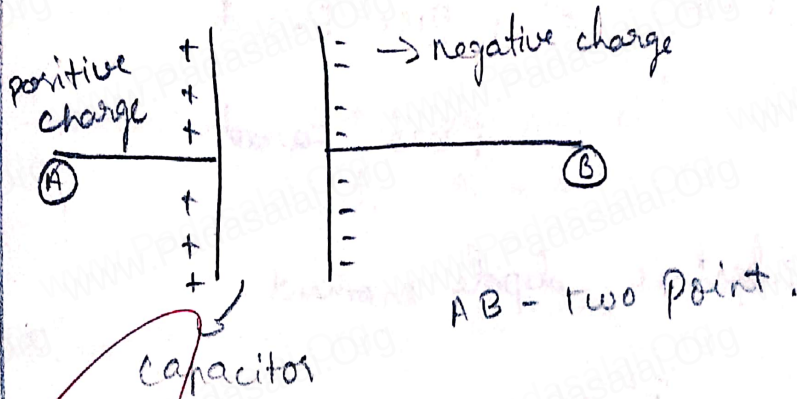
$\downarrow$
Not Equilibrium.

Capacitance of conductor

↓
கனம் கருத்து.

Electric charge storage Device.

Symbol.



$$C = \frac{Q}{V}$$

C = Capacitance of conductor.

Q = Quantity of charge or
magnitude of charge
(length)

V = Potential Difference.

1. $V = ?$

$$C = \frac{Q}{V}$$

$$V = \frac{Q}{C}$$

2. $Q = CV$

unit = farad.

1 μ F = 1 micro Farad
 1×10^{-6} Farad

1 pF = 1 pico Farad
 1×10^{-12} Farad.

Electric dipole moment.

$$\vec{p} = q \times 2a$$

q = charge

$2a$ = Very small distance

$\times$ = Product

p = Electric dipole moment

unit C.m $\rightarrow$ coulomb metre

Quantity $\Rightarrow$ vector Quantity

mark

- 1) 1 nC = one nano coulomb $\rightarrow$ charge
- 2) 1 pF = one pico Farad $\rightarrow$ capacitor
- 3) 1 μ f = one micro Farad
- 4) 1 n f = one nano Farad

- 5) Capacitance unit = Farad
- 6) Capacitance practical unit = μF , pF
- 7) What is meant by Capacity —
charge storage Device.
- 8) Electric dipole moment quantity — ?
Vector Quantity
9. Quantisation of electric charge — ?
 $q = ne$
10. $V = ?$ potential difference.

5 mark.

Capacitor series connection.

Capacitor

charge storage device.

$$C = \frac{Q}{V}$$

$C \rightarrow$ capacitance of conductor

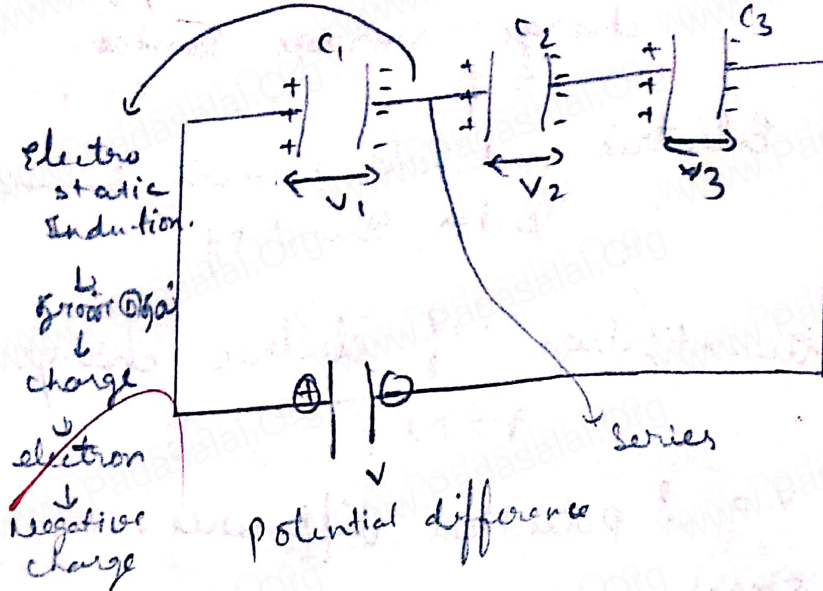
$Q \rightarrow$ magnitude of charge

$V \rightarrow$ potential difference.

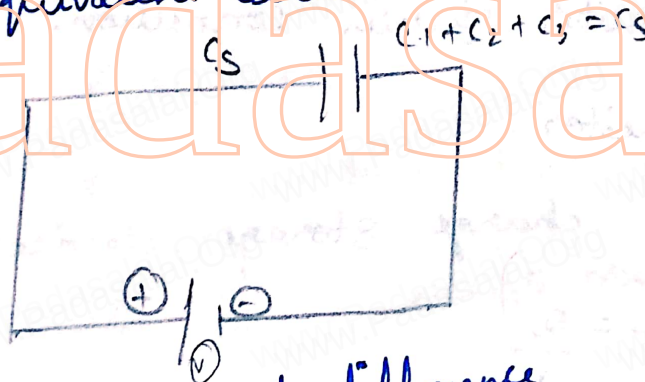
unit $\rightarrow$ farad.

Potential unit : $1 \mu F$ and $1 pF$
 (10^{-6}) (10^{-12})

Capacitor Series



Equivalent Series



potential difference

Potential difference

$$V = V_1 + V_2 + V_3$$

$$C = \frac{Q}{V}$$

$$V = \frac{Q}{C}$$

$$V_1 = \frac{Q}{C_1}, \quad V_2 = \frac{Q}{C_2}, \quad V_3 = \frac{Q}{C_3}$$

$$V = V_1 + V_2 + V_3$$

$$V = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$V = Q \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)$$

$$V = \frac{Q}{C_s}$$

~~$$V = \frac{Q}{C_s} = Q \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)$$~~

$$\frac{Q}{C_s} = Q \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)$$

$C_1 + C_2 + C_3 \rightarrow$ capacitor.

$$Q \left(\frac{1}{C_s} \right) = Q \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)$$

$$\frac{1}{C_s} = \frac{Q}{Q} \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)$$

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

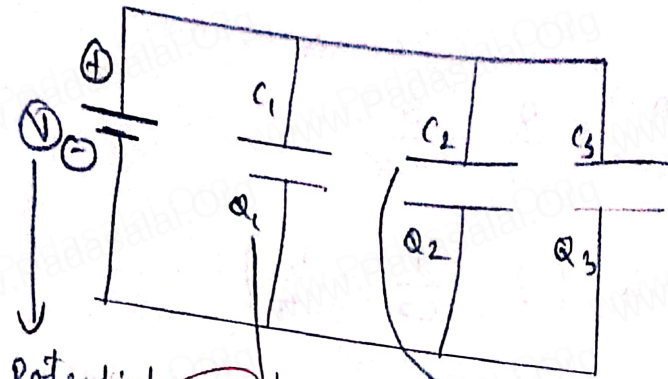
↓
Series
capacitor

↓
Individual capacitor less
than



Capacitors parallel connection

$$C = \frac{Q}{V}$$



Potential difference

Charge

Electro static Induction

↓
Negative charge
electron

Equivalent parallel connection



$$Q = Q_1 + Q_2 + Q_3$$

$$C = \frac{Q}{V}$$

$$Q = CV$$

$$Q_1 = C_1 V$$

$$Q_2 = C_2 V$$

$$Q_3 = C_3 V$$

$$Q = Q_1 + Q_2 + Q_3$$

$$Q = C_1 V + C_2 V + C_3 V$$

$$= V (C_1 + C_2 + C_3)$$

$$Q = C_p V$$

$$C_p V = V (C_1 + C_2 + C_3)$$

$$C_p = \frac{Q}{V} (C_1 + C_2 + C_3)$$

$$C_p = (C_1 + C_2 + C_3)$$

↓
Parallel
connection
capacitor.

↓ Individual
Capacitor.
↓
(greater than)

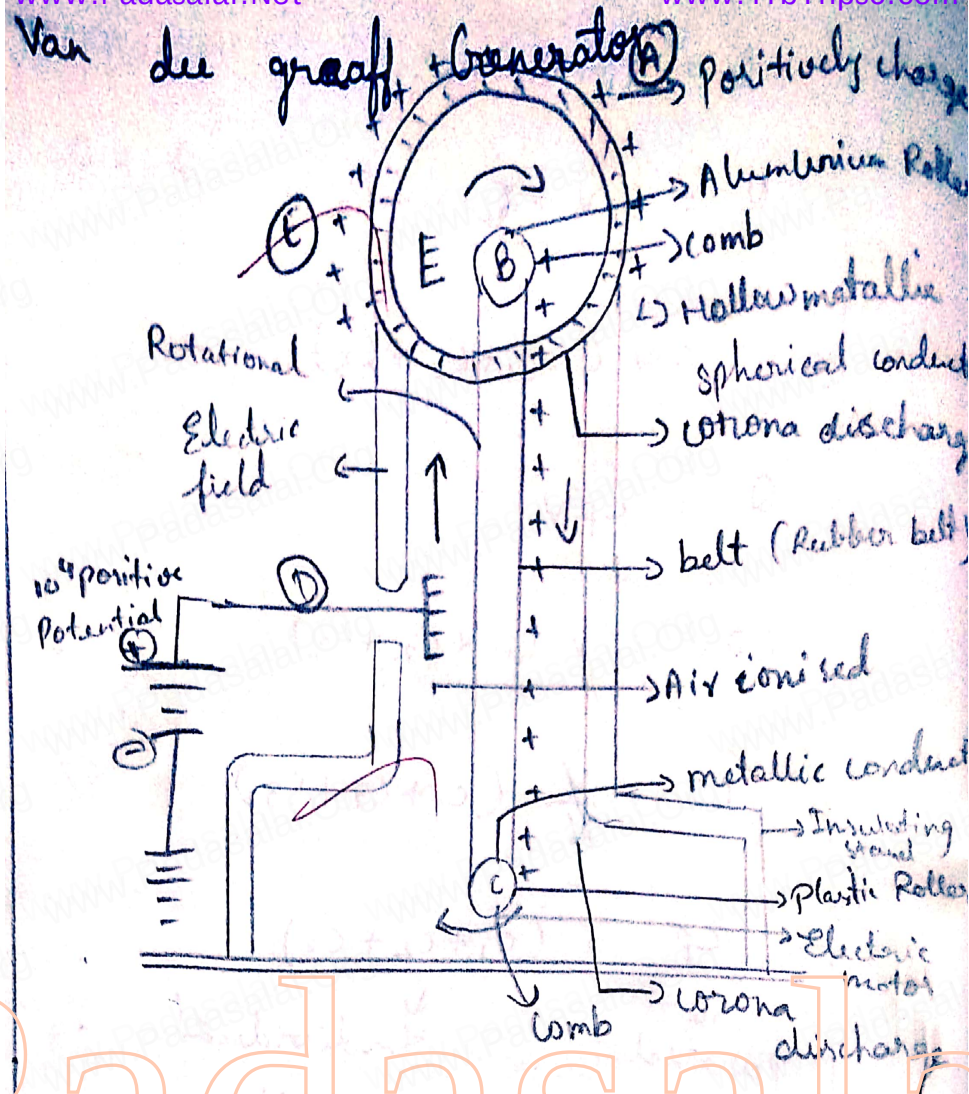
Van der graaff Generator (1729)

J. van der graaff.
↓
Robert

Physical → Interaction.

Chemical → Reaction.

~~27/06/19~~



Principle

i) Electrostatic Induction. (சுருள் தாது)

ii) Action of points or corona discharge
↓
leakage of charge

Limit $\rightarrow (10^7 \text{ v})$

large amount of Electrostatic Potential

difference (10^7 v)
are

Positive ions accelerated (proton,
deuteron).

Charge

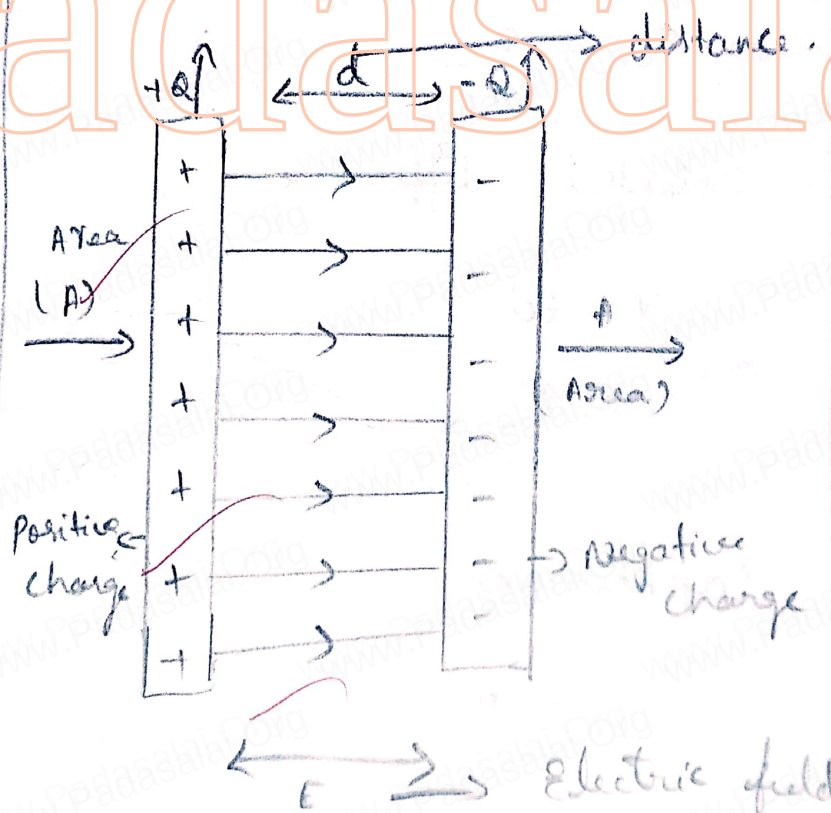
Positive charge $\rightarrow$ Negative ions

Negative charge $\rightarrow$ Positive ions

Cathode $\rightarrow$ Negative charge
(Cation) $\downarrow$
Positive ions

Anode $\rightarrow$ positive charge
(Anion) $\downarrow$
Negative ions

~~Smart~~
Capacitance of a parallel plate capacitor.



Capacitor

charge storage device

Electric field

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

σ = charge density

$$\sigma = \frac{Q}{A}$$

$Q \rightarrow$ magnitude of charge

$A \rightarrow$ cross sectional Area

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

$$E = \frac{Q}{A \epsilon_0}$$

potential difference

$$V = Ed$$

$$V = \frac{Q}{A \epsilon_0} d$$

Capacitance

$$C = \frac{Q}{V}$$

$$C = \frac{Q}{\frac{Q}{A \epsilon_0} d}$$

$$C = \frac{\epsilon_0 A}{d}$$

Energy stored In a Capacitor.

Capacitor

Charge storage device.

Energy stored in a capacitor.

work done.

↓

பொருள்

நேரம்.

$$dw = V dQ \quad \begin{array}{l} \text{magnitude of charge} \\ \text{potential difference} \end{array}$$

work done

$$dw = V dQ$$

Capacitor

$$C = \frac{Q}{V}$$

$C \rightarrow$ capacitance of conductor.

$Q \rightarrow$ magnitude of charge.

$V \rightarrow$ potential difference.

$$C = \frac{Q}{V}$$

$$V = \frac{Q}{C}$$

$$dw = v da$$

$$dw = \frac{Q}{C} da$$

$$\text{Integral } dw = \frac{1}{C} Q da$$

$$\int dw = \int \frac{1}{C} Q da$$

$$\int y dx = x$$

$$W = \frac{1}{C} \int Q da$$

$$\int dy = y$$

$$W = \frac{1}{C} \frac{Q^2}{2}$$

$$\int dz = z$$

$$\int dv = v$$

$$W = \frac{1}{2C} Q^2$$

$$\int da = a$$

Capacitance of Conductor.

$$\int dr = r$$

$$C = \frac{Q}{V}$$

$$\int x dx = \frac{x^{n+1}}{n+1}$$

$$CV = Q$$

$$W = \frac{1}{2C} Q^2$$

$$\int Q da = \frac{Q^{n+1}}{n+1}$$

$$W = \frac{1}{2C} (CV)^2$$

$$\int Q da = \frac{Q^2}{2}$$

$$W = \frac{1}{2C} C^2 V^2$$

$$W = \frac{C^2 V^2}{2C}$$

$$W = \frac{1}{2} CV^2$$

$$W = U_E$$

$U_E \rightarrow$ potential energy

$$U_E = \frac{1}{2} CV^2$$

$$C = \frac{\epsilon_0 A}{d}$$

$$U_E = \frac{1}{2} \left(\frac{\epsilon_0 A}{d} \right) V^2$$

$\epsilon_0 \rightarrow$ Permittivity of free space

$\epsilon_0 \rightarrow 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$
Coulomb Newton

$A \rightarrow$ Cross sectional Area (Length $\times$ Breadth)

$d \rightarrow$ distance of the plate.

$$V = Ed$$

$$U_E = \frac{1}{2} \left(\frac{\epsilon_0 A}{d} \right) (Ed)^2$$

$$U_E = \frac{1}{2} \left(\frac{\epsilon_0 A}{d} \right) (Ed)^2$$

$$U_E = \frac{1}{2} \left(\frac{\epsilon_0 A}{d} \right) E^2 d^2$$

$$U_E = \frac{1}{2} \epsilon_0 A E^2 d$$

$$U_E = \frac{1}{2} \epsilon_0 E^2 (Ad)$$

Ad = Volume of the space in a plate

$$U_E = \frac{1}{2} \epsilon_0 E^2$$

One mark.

* Electric flux unit is $\text{Nm}^2 \text{C}^{-1}$

* Gauss's law formula : $\Phi_E = \frac{Q}{\epsilon_0}$

* Capacitor unit is Farad

* Insulator example any two mica, cedar
efonite

* Electric flux Scalar Quantity

Shanmugam