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CHAP: 1

"ELECTROSTATICS"

CHARGE:

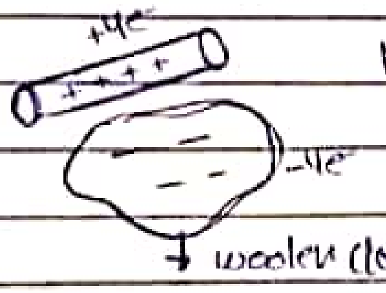
=> property which produced Electric field

=> This is conserved & quantized.

$\boxed{q = ne}$ → charges are quantized i.e $1e, 2e, 3e, \ldots$

→ smallest charge in nature

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



Net charge produced is always zero i.e conserved

$+4e - 4e = 0e^-$

ELECTRIFICATION:

=> process of charging of bodies

① => By conduction → physical contact is used

② => By Induction → just field Interaction.

CHARGE DENSITY:

charges per unit dimension (l, A, V)

① LINEAR CHARGE DENSITY:

$\rho_l = q/l$ → $\rho_l \propto q$, $\rho_l \propto 1/l$

② SURFACE CHARGE DENSITY:

$\rho_A = q/A$ → $\rho_A \propto q$, $\rho_A \propto 1/A$

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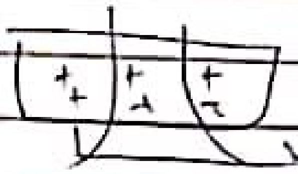
③ VOLUME CHARGE DENSITY:

$$\rho_v = \frac{q}{V} \quad \rightarrow \rho_v \propto q, \quad \rightarrow \rho_v \propto 1/V$$

Uniform Charge Distribution:

=> charge density is constant

If we divide a sheet → and sheet is uniformly charge distributed & we divide the sheet into 3 parts then the surface charge density on all the parts will be same.



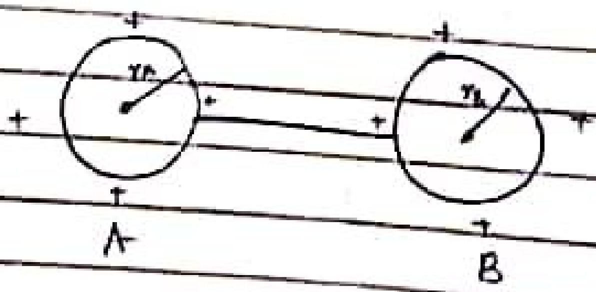
same.

on all the parts will be same!

CHARGES → cause → ΔV → difference in charge density

=> charges will flow b/w 2 bodies unless charge density becomes same.

MCQ:



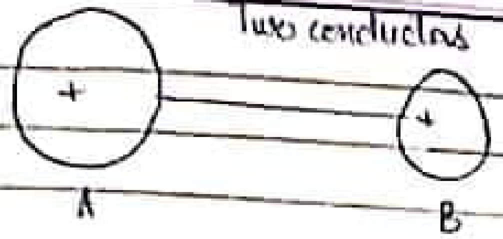
$q_A = q_B$ same

so; no charges flow coz $\Delta V = 0$ so potential = const and $I = 0$

If r ≠ constant then $\Delta V \neq 0$

MCQ:

Two conductors



(b)

mag q $\rightarrow$ $q_A = q_B$, $r_A > r_B$

Correct statement:

(a) charges flow from A to B
(b) from B to A
(c) no charges flow
(d) none

more radius $\rightarrow$ less charge density so charges will flow from B to A

$\sigma \propto 1/r$

less size $\rightarrow$ more charge density so flow is from high charge density to low charge density

COULUMB'S LAW:

$F \propto q_1 q_2$ (r & medium = constant)

$F \propto \frac{1}{r^2}$ (q_1 & q_2 & ε_m = constant)

$F \propto \frac{1}{\varepsilon_r}$ or $F \propto \frac{1}{\varepsilon_m}$ ($q_1 q_2$ & r = constant) (permittivity of medium)

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

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

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

or

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

$F_m = \dfrac{F_v}{\varepsilon_r}$ $\qquad \varepsilon_r = \dfrac{1\ \text{vac}}{1\ \text{med}}$

$\boxed{\varepsilon_r = \dfrac{\varepsilon_m}{\varepsilon_0}}$ → permittivity of medium
→ permittivity of free space/vacuum

relative permittivity

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

for vacuum

$\boxed{\varepsilon_r = 1}$

for air

$\boxed{\varepsilon_r = 1.0006}$

for all other mediums

$\boxed{\varepsilon_r > 1}$

$\boxed{\varepsilon_r = \dfrac{F_v}{F_m}}$

$\boxed{\varepsilon_r^{-1} = \dfrac{1}{\varepsilon_r} = \dfrac{F_m}{F_v}}$

M.C.Q:

$F_v = 40N \quad F_m = 5N$ $\qquad$ (a)

$\varepsilon_r = ? \quad \varepsilon_r = F_v / F_m = 8$

(a) 8 $\quad$ (b) 16 $\quad$ (c) 40 $\quad$ (d) 5

ε_r = dimensionless

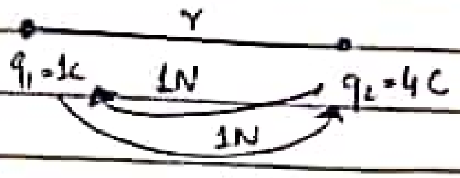
ε_m = not dimensionless

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

Coulomb's law also obey newton's 3rd law.

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

Coulombic force is a mutual force.



If q_1 exerts 1N force on q_2 then q_2 will exert same force on q_1 i.e $F_{12} = -F_{21}$ & q_2 will not exert 4N force.

MCQ: [redacted]

$q_1 = 8C$ —— x − 5C

$q_2 = 3C$ —— x − 5C

$F_1 = F$ $\quad\quad q_1 \times q_2 = 24\ C$

$F_2 = ?$ $\quad\quad q_1' \times q_2' = -6\ C$

$q_1' = 3C$ $\quad\quad \frac{24}{?} = 6$

$q_2' = -2C$

so: $\frac{24}{4} = 6$

$q_1' q_2'$ decreases 4 times so force will be decrease 4 times so;

$F_2 = F/4$

or

$F_2 = -F/4$

• ELECTRIC FIELD INTENSITY:

$E = F/q_0$ $\quad q_0 \rightarrow$ test charge.

$\quad q \rightarrow$ source charge.

$\downarrow$ field strength of source charge.

To test field of source charge.

$$\boxed{q_0 << q}$$

$$\vec{E} = \lim_{q_0 \to 0} \vec{F}/q_0$$

$\boxed{E = F/q_0} \rightarrow$ analogue of $\boxed{g = \frac{w}{m}} \rightarrow$ gr. field streng.

Unit: $N/C = V/m$

$\vec{E}$ is a vector

① has mag $E = F/q_0$.

② direction $\rightarrow$ as that of $E = F/q_0$
force

Electric field Intensity due to pt charge:

$$E = Kq/r^2$$

or

$$E_s = \frac{1}{4\pi\epsilon_0} \times q/r^2$$

or

$$E_m = \frac{1}{4\pi\epsilon_m} \times q/r^2$$

$$E_m = \frac{1}{4\pi\epsilon_0\epsilon_r} \times q/r^2$$

$\rightarrow E \propto q$

$\rightarrow E \propto 1/r^2$

$\rightarrow E \propto 1/\epsilon_m$ or $E \propto 1/\epsilon_r$

- Primary source to observe electric field is test charge.

$E = ?$

&

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

$$\Rightarrow \boxed{\varepsilon_r = \frac{E_{vacc}}{E_{med}}} \quad \boxed{E_{med} < E_{vacc}}$$

streng-

- **Electric polarization:**

Slightly displacement b/w nucleus & electrons of an atom known as electric polarization.

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

- **permitivity:**

The capability of medium to polarize → permitivity.

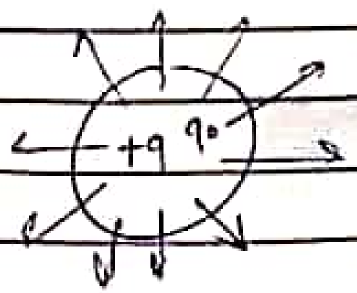
⇒ Coulombs law is only applicable for pt charges & is always known as "Action of at distance Law".

ELECTRIC FIELD LINES:

Electric field.

⇒ This is a vector field & a real field

⇒ The imaginary lines drawn in the direction of force → electric field lines.

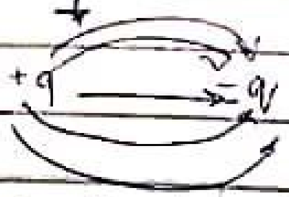


for +ve test charge : positive source charge is source of field lines & -ve source charge is sink of field lines. & opp for -ve ch

→ Infinite field lines can be drawn around a single charge.

→ Field lines are discrete and not continuous.

→ field lines can be straight or curved.



B/w 2 similar charges → there is a pt where $E = 0$ but only at a single pt.

$E = 0$ $\quad E_1 = E_2$

$+q_1 \xrightarrow{E_1} \uparrow \xleftarrow{E_2} +q_2$ $\quad q_1/r_1^2 = q_2/r_2^2$

B/w similar charges, there will be single point on a line joining two charges where $E = 0$ (null pt)

but b/w 2 opposite charge, null pt donot lie on line joining two opp charges, b/w 2 charges.

$E \neq 0$

$+q_1 \rightarrow q_0 \longrightarrow -q_2$

$$E_1 = E_2$$

$$\frac{q_1}{r_1^2} = \frac{q_2}{r_2^2}$$

$\frac{q}{r^2}$ = constant (at null pt)

$$\boxed{q \propto r^2}$$

$$\boxed{r \propto \sqrt{q}}$$

$$\frac{r_1}{r_2} = \sqrt{\frac{q_1}{q_2}}$$

MCQ.

$q_1 = 1C$

$q_2 = 4C$ $\quad \frac{r_1}{r_2} = \sqrt{\frac{q_1}{q_2}}$

$r = 3m$

$$\frac{r_1}{r_2} = \sqrt{\frac{1}{4}}$$

$\frac{r_1}{r_2} = \frac{1}{2}$] sum the ratio & divide the total dist on by that sum.

$\frac{r_1}{r_2} = \underbrace{1m : 2m}_{1+2=3m}$ $\quad r_1 = 1m \; ; \; r_2 = 2m$

MCQ. trick → divide the given distance in ratio

$q_1 = \cancel{9C}$ $\quad$ (d $q_1 = 6C$

$q_2 = \cancel{1C}$ $\quad q_2 = 2C$

where distance b/w charges is 8cm then pt where electric field intensity will be 0 will be ——

(a) 2cm from q_2 & 6cm from q_1 (a)

(b) 6cm from q_2 & 2cm from q_1

(c) 3cm from q_2 & 5cm from q_1

(d) None

$$\frac{r_1}{r_2} = \sqrt{\frac{q_1}{q_2}}$$

$$\frac{r_1}{r_2} = \sqrt{\frac{6C}{2C}} = \sqrt{\frac{6}{2}}^{3}$$

$$\frac{r_1}{r_2} = \frac{\sqrt{3}}{1} = \frac{\sqrt{3}}{1}$$

$$\frac{r_1}{r_2} = \sqrt{3} : 1$$

If $q_1 = 9C$ (a)

$q_2 = 1C$

$\frac{r_1}{r_2} = 3 : 1$

sum = 4

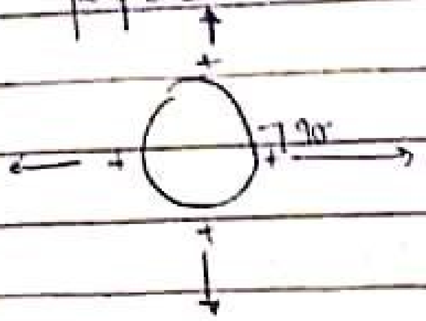
give $r = 8cm$ so $\times$ 4 with a no so we get 8 i-e $\frac{8}{4} = 2cm$.

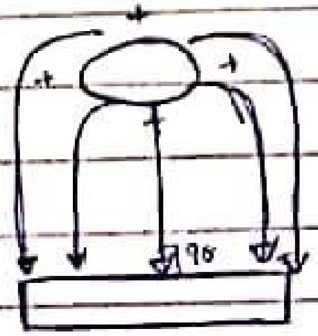
1 part = 2cm $\quad$ ($\overset{(2\times3)}{3} : 1$)

$\frac{r_1}{r_2} = 6cm : 2cm$

= divide the given distance in the given ratio simply

→ Electric field lines will always originate perpendicular & also terminate perpendicular → cos if other θ (angle) then the lines will overlap.

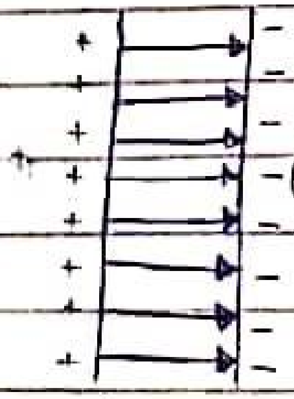




Uniform field:

→ constant magnitude & constant direction ($\vec{E}$ = constant)

⇒ 100% uniform field can't be produced but electric field b/w 2 oppositely charged plates having infinite length & negligibly small separation is approximately uniform



If field is uniform the 'E' will be independent of 'r' (distance)

→ Electric field around a pt charge can never be zero. then $E \propto 1/r^2$ and for uniform E → independent of 'r'.

+q $\xrightarrow{1cm}$ E $E_1 = 4N/C$

2cm $E_2 = 1N/C$

$E_6 = 1N/$...

APPLICATION OF ELECTROSTATICS:

XEROGRAPHY.

Working Principles

-) neutralization of charges / electrostatic interaction

-) Aluminium drum → heart of Photocopier machine.

-) page is more +vely charged than aluminium drum.

Electric Flux :

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

$$\phi_e = EA\cos\theta$$

$$E = \frac{\phi_e}{A\cos\theta}$$

-ve flux → inward flux.

$$\theta = 0^\circ$$

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

$$\boxed{E = \frac{\phi_e}{A}} \text{] field lines density}$$

$$\boxed{E \propto \text{field lines density}} \rightarrow \phi_e/A$$

$\phi_e = 10 Nm^2/C$

$A = 1 m^2$

$E = 10$ field lines per 1 m^2 area.

$E \propto q$

$\boxed{\text{Electric field line density} \propto \text{charge } (q)}$

GAUSS'S LAW. (Generalized form of Columb's Law)

$\phi_e = \vec{E} \cdot \vec{A} \rightarrow$ for open / flat area

flat area $\rightarrow$ vector area

closed area $\rightarrow$ never a vector

flux through closed surface

$$\phi_{eT} = \sum_{i=1}^{n} \vec{E_i} \cdot \vec{\Delta A_i}$$

$$\phi_{eT} = \vec{E_1} \cdot \vec{\Delta A_1} + E_2 \cdot \vec{\Delta A_2} + \cdots + \vec{E_n} \vec{\Delta A_n}.$$

→ Coulombs law is only for point charges.
→ Guasses law is for point charges + distribution of charges.

Total flux is equal to $1/\varepsilon_0$ the total charge enclosed

$$\phi_{eT} = \frac{1}{\varepsilon_0}(Q) \qquad eT \rightarrow \text{total electric flux}$$

$$\phi_{eT} = \frac{Q}{\varepsilon_m}$$

→ Guass's for 1st time measured magnitude of charge from flux.
source

$$Q = \varepsilon_0 \phi_{eT}$$

$$Q = \phi \varepsilon_0$$

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$Q = \epsilon_m \phi_{cT}$

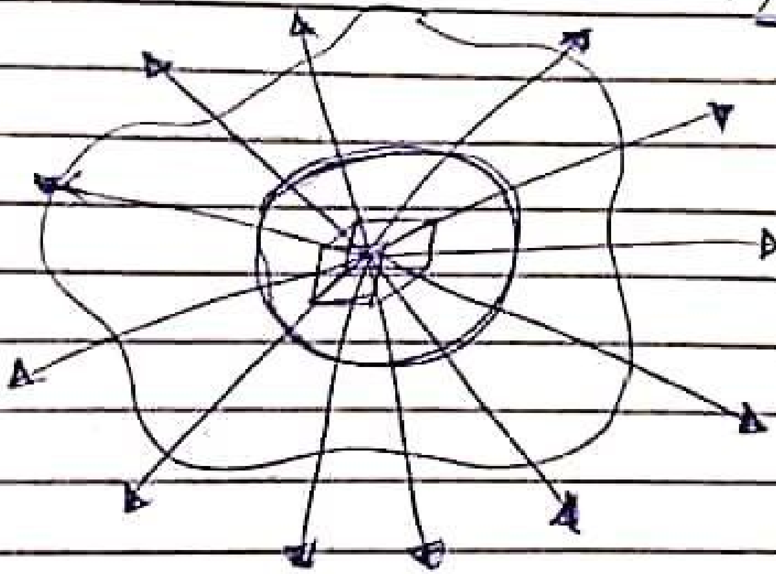
$$\boxed{Q = \epsilon_r \epsilon_0 \phi_{cT}}$$

→ Gauss's law is only for closed surfaces.

$\phi_{cT} \propto Q$ (ϵ_m - constant)

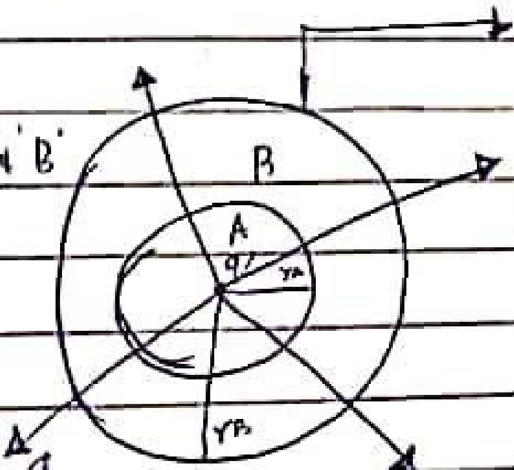
$\phi_{cT} \propto \frac{1}{\epsilon_m}$ (Q = constant)

→ Independent of (i) shape of closed surface
(ii) size of closed surface



flux through all the surfaces is same either cube sphere or arbitary body

If 2 spheres 'A' & 'B' and $r_B > r_A$ then and charge lie at the centre of sphere then correct stateme-



:- Correct Statement (a)

(a) flux $\phi_A = \phi_B$

(b) $\phi_A > \phi_B$

(c) $\phi_A < \phi_B$

(d) None

⇒ i.e flux through both spheres.

Two spheres of radius r_A & r_B which is concentric & 'q' charge lie at the centre of 2 spheres then which statement is correct about flux through unit area of both sphere. $r_B > r_A$ $\quad \phi \propto 1/r^2$ (b)

(a) $\phi_A = \phi_B$ $\qquad$ (b) $\phi_A > \phi_B$

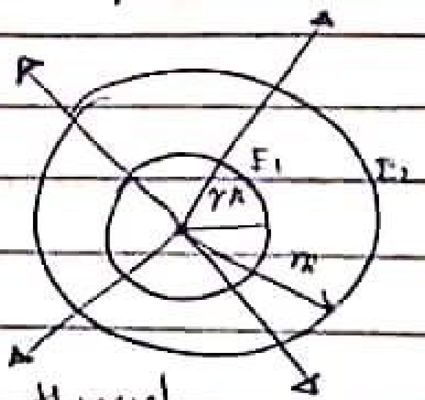
(c) $\phi_A < \phi_B$ $\qquad$ (d) None

Flux:

as unit area → so same area and not mentioned ~~& close or open surface~~.

$$\phi = EA = \frac{kq}{r^2} \times A$$

$$\phi \propto 1/r^2 \qquad \phi_A > \phi_B$$



$E_1 \neq E_2$

$E \propto 1/r^2$

$E_1 > E_2 \; (r_B > r_A)$

flux through both sphere = same

flux through unit area is not same

$\downarrow$ E

flat area is given

close area = same flux → independent on "r"

unit flat area – diff flux → depends on "r"

$r_A = 1cm$

$E_A = 4N/C$ $\qquad E_B = 1N/C \qquad E \propto 1/r^2$

$E_B = ?$ $\qquad \frac{E_B}{E_A} = \frac{r_A^2}{r_B^2}$

$r_B = 2cm$

Flux:

(a) $\phi_{eT} = +q/\varepsilon_0$

→ If flux = +ve

→ outward flux

→ Q = +ve

(b) $\phi_{eT} = -q/\varepsilon_0$

→ If flux = -ve

→ Inward flux

→ Q inclosed is -ve.

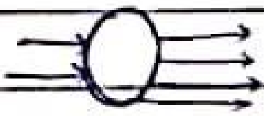
Imp Concept:

$\phi_{net} = -ve$ (flux)

$Q_{enc} = -ve$ (charge)

cos inward flux is more than outward flux.

or inward flux < outward flux



$\phi_{net} = +ve$

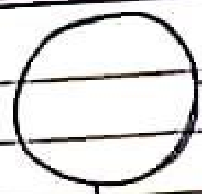
$Q_{enc} = +ve$

inward flux > outward flux

-ve > +ve

$\phi_{net} = 0$

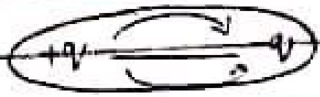
$Q_{encl} = 0$

q 

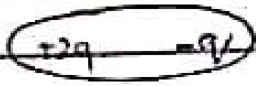
$\rightarrow Q = 0$

$\phi_{et} = 0$ $\qquad$ $\phi_{et} = q/\epsilon_0$

no charge enclosed so $Q = 0$ & $\phi = 0$

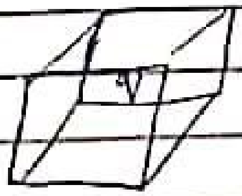


$q_{net} = 0$ $\qquad$ $q_{net} = -q + q = 0$



$q_{net} = +ve$

$\phi_{net} = +ve$



$\phi_{net} = q/\epsilon_0$

$\phi = \frac{1}{6}\left(q/\epsilon_0\right)$

from 2 faces

$\phi = \frac{2}{6}\left(q/\epsilon_0\right)$

from 3 faces

$\phi = \frac{3}{6}\left(q/\epsilon_0\right)$

from half faces

$\phi = \frac{3}{6}\, q/\epsilon_0$ or $\frac{1}{2}\left(q/\epsilon_0\right)$

Application

(i):-

(ii):-

Depend

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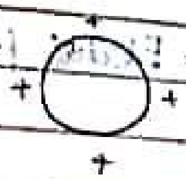
Application Of Gauss's Law:

(i) :-

$E = 0$ inside a charged conductor

↓

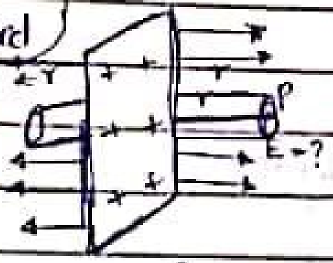
Electrostatic Equilibrium:



→ Electric field lines doesn't passes through conductor.

(ii):- Electric field intensity due to Infinite sheet of charge:

If charges are distributed uniformly then E is indendent on distance 'r'



$l = 2r$

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

Dependence: ① magnitude of charge, ② surface area & ③ medium.

$\sigma = q/A$

$$E = \frac{Q}{2A\epsilon_0}$$

$$E_m = \frac{Q}{2A\epsilon_m}$$

$$E = \frac{Q}{2A\epsilon_r\epsilon_0}$$

/ $E = -\frac{\sigma}{2\epsilon_0}$ (-ve charge distribution).

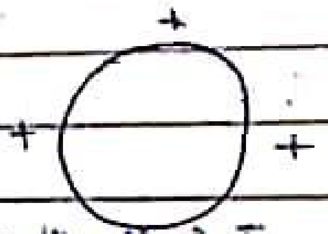
E is always normal to the surface.

$$\vec{E} = \frac{\sigma}{2\epsilon_0}\hat{n}$$

If charge distribution is uniform then field on b/s will be same.

(iii): Electric field intensity inside + outside a shell:
a hollow body.

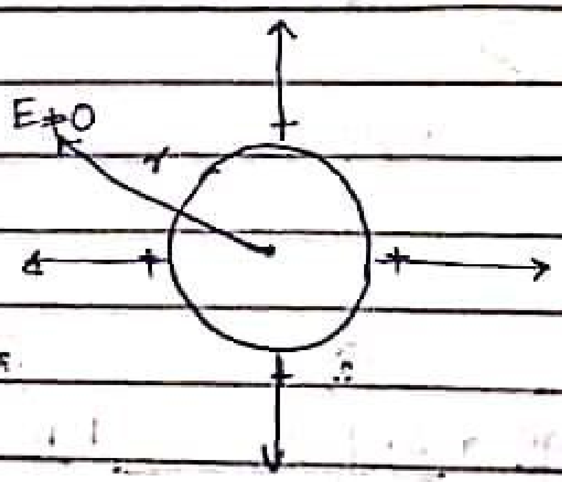
Case a:



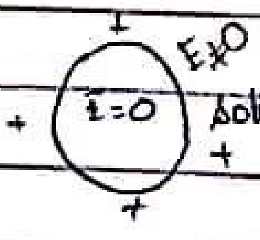
Inside → E = 0 (q = 0)

Case b:

Outside a shell:



⇒ for outside points charge conductor will behave like a point charge lie at the centre of charged shell



solid cylinder $E_{inside} = 0$

$E_{outside} \neq 0$

(iv) Electric field intensity due to oppositely charged sheet:

$\sigma_A = \sigma_B$

$E = \frac{\sigma}{\varepsilon_0}$ If $\sigma_A = \sigma_B$

$E = \frac{Q}{A\varepsilon_0}$

If $\sigma_A \neq \sigma_B$
then

$$\boxed{E = \frac{\sigma_A}{2\epsilon_0} + \frac{\sigma_B}{2\epsilon_0}}$$

If $\sigma_A = \sigma_B$

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

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

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

→ If oppositely charged sheets
E

$E = 2\sigma_s$ (single sheet)

2 opp charged sheets ← $E = 2E_s$ (single sheet)

$$\frac{E}{E_s} = 2$$

opp charge plates — due to 2 opp charge plates = E then if we remove 1 sheet then $E/2$

and if 1 sheet + other is ~~removed~~ added then
$E = 2E$

Same [$E = 0$

(i) $E = 0$
If $\sigma_A = \sigma_B$

(ii) If $\sigma_A > \sigma_B$
then $E_A > E_B$

E_{net} directed along E_A ...

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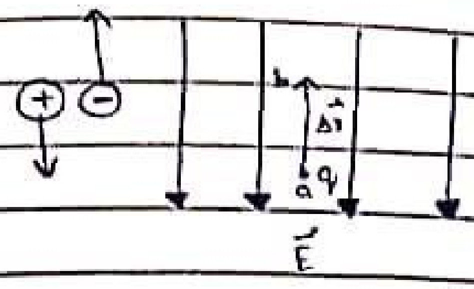
If we construct a surface below the -ve charge then E ≠ 0 coz charge enclosed ≠ 0

- ELECTRIC POTENTIAL ENERGY:



If we do work against field then work will be store as energy (P.E).

$W_{a\to b} = \Delta U = U$ → electric potential energy

If V = constant

If $(+q)$ → in direction of Electric field

If V ≠ constant (velocity)

a ≠ 0

$W_{a\to b} \neq \Delta U$

b/c of energy lost.

Electric Potential is the work done per unit charge

or

P.E change per unit charge.

$$\Delta V = \frac{W_{a\to b}}{q_0}$$

or

$$\Delta V = \frac{\Delta U}{q_0}$$

$$\boxed{V = \frac{W}{q_0}}$$

$1\,\text{volt} = 1\text{J}/1\text{C}$

Potential Energy = Total work done $= W$

Potential = work done per unit charge $= W/q_0$

→ ABSOLUTE ELECTRIC POTENTIAL:

$$V = \frac{Kq}{r}$$

$$V_v = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$V_{med} = \frac{1}{4\pi\varepsilon_m} \times \frac{q}{r}$$

or

$$V_m = \frac{1}{4\pi\varepsilon_r\varepsilon_0}\frac{q}{r}$$

$$V_m = \frac{V_v}{\varepsilon_r}$$

$$\boxed{\therefore V_m < V_v}$$

$V \propto q$ → source charge.

$V \propto 1/r$

$V \propto 1/\varepsilon_m$ or $V \propto \frac{1}{\varepsilon_r}$

$$\boxed{\varepsilon_r = \frac{V_{vac}}{V_{med}}}$$

$$\frac{1}{\varepsilon_r} = \frac{V_{med}}{V_{vac}}$$

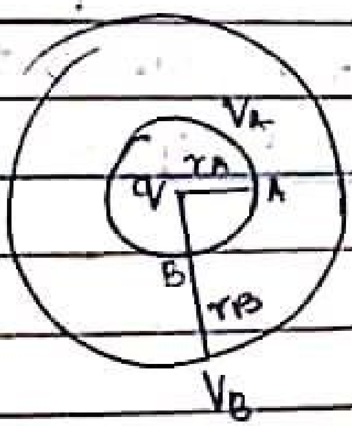
MCQ: At some pt, at 'r' distance source charge 'q' (c) Electric field intensity were "E" and electric potential were "V". Now at some other point electric field intensity is $E/4$ then potential at this point will be ___

(a) $V/4$ (b) $4V$

(c) $V/2$ (d) V

~~$\therefore E \propto 1/r^2$ & $V \propto 1/r$~~

$E \propto 1/(2)^2$ & $V \propto 1/2$



$\therefore V_A > V_B$

co2

$V \propto 1/r$

$r_B > r_A$

If $r_B = 2r_A$

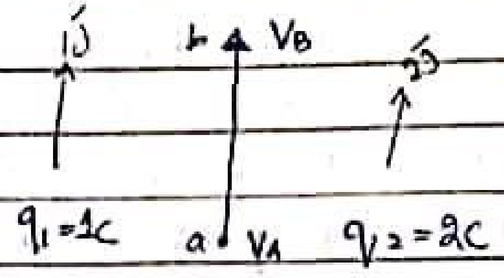
$V_B = V_A/2$

$\boxed{V \to \text{independent of magnitude of test charge.}}$

$\boxed{\text{but } E \to \text{depends upon mag of test charge}}$

$F = q_0 E$

$W = q_0 E \Delta r$ or $W = q_0 E \Delta r \cos\theta$



$$\boxed{\begin{array}{c} W \propto q_0 \\ W \propto E \\ W \propto \Delta r \end{array}}$$

Work done depends on mag of test charge.

$\Delta V = W/q_0$

If ; $\Delta V = 1J/1C = 1V$

$\Delta V = 2J/2C = 1V$

$\Delta V = 10J/10C = 1V$

coz if we do work the of 1J on 1C charge then if we do work of 10J the charge will be 10C coz $\boxed{W \propto q_0}$

here 'W' & P.E will not be same but 'V' = 0 'V' will be same for coz independent of q_0 but depends on mag of source charge q.

- **Equipotential Surface:**

Surface at which electric potential is constant or same.

- **Equipotential lines/circles:**

V = constant.

$V_A > V_B > V_C$ $(r_C > r_B > r_A)$

but $V_1 = V_2 = V_3$

coz 'r' is same 'a' is

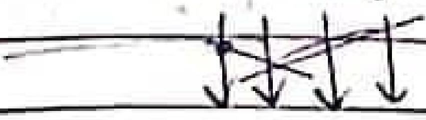
equipotential line

$V_A = V_B = V_C$

equipotential surface

$V_x = V_y = V_z$

equipotential line & surface is always perpendicular to electric field line.



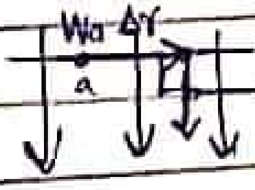
$V_D \neq V_E$

they can't overlap and are not perpendicular.

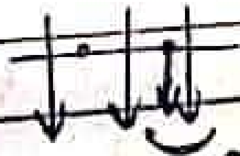
* $\boxed{\text{Work done to move a charge on equipotential surface or equipotential line is zero.}}$

$\cos \theta = 90°$

* But if we move charge b/w 2 equipotential surface or line/circle, then work done will be non-zero.



$\theta = 90°$ $W = 0$



$\theta = 0°$

Potential Gradient:

Gradient → change w.r.t distance / displacement
($\Delta/\Delta r$)

E = negative gradient of electric potential.

$E = -\frac{\Delta V}{\Delta r}$ → $E = \Delta V/\Delta r$ → E → −ve (opp to direction of $\vec{E}$)
ΔV = +ve
V → increases

→ E → +ve (in the direction of E).
ΔV = −ve
V → decreases

$-E = \Delta V/\Delta r$ →

we move
If +ve test charge in the direction of E Then V → decreases & opp to E then V → increases. and If perpendicular then V=0

and if −ve test charge then along $\vec{E}$ then V → increases and opp V → decreases.

gradient (scalar) = vector
ΔV (di) = $\vec{E}$

$E = \Delta V/\Delta r$

$\Delta V = E\Delta r$

$\boxed{V = Ed}$

K. Energy

K. Energy Of Charge: → accelerating by using potential:

$$K.E = q\Delta V$$
$$E.E = qV$$

for speed:

$$\frac{1}{2}mv^2 = qV$$

$$\boxed{v = \sqrt{\frac{2qV}{m}}}$$

Electron Volt: → unit of energy (smaller)

$$1eV = 1.6\times10^{-19}J$$

$$n(1eV) = n(1.6\times10^{-19}J)$$

$$1J = \frac{1}{1.6\times10^{-19}} eV$$

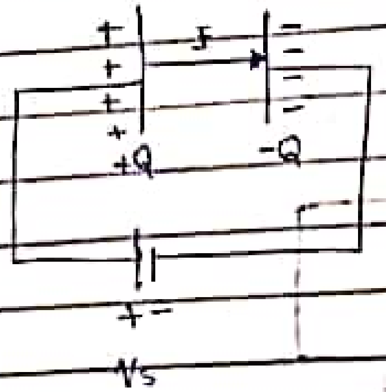
$$n(1J) = n\left(\frac{1}{1.6\times10^{-19}} eV\right)$$

$$\boxed{E = qV}$$

CAPACITOR:

Device used to store electrical charges & electrical energy.

$V_c = E_c d_c$



net

$Q_{net} = Q - Q = 0$

$|Q| = |-Q| = Q$

magnitude of charge

during charging $V_c < V_s$

but when capacitor is fully charged

$V_c = V_s$

$V_{max} = V_s$ $\quad (V_c = V_s = V_{max})$

$Q \propto V$

$\boxed{Q = CV}$

unit → farad → larger unit

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

$\boxed{C \rightarrow \text{independent of } Q \text{ \& } V}$

$C = Q/V$ → always constant.

C → depends upon

(a) geometric shape

(b) dimension (l, A, V)

(c) separation b/w plates

(d) medium

$\epsilon_r = \frac{F_v}{F_m}$ $\epsilon_r = \frac{V_v}{V_m}$ $\epsilon_r = \frac{I_v}{I_m}$ $\epsilon_r = \frac{C_m}{C_v}$

$\epsilon_r = K_v/K_m$ $\epsilon_r = \frac{\epsilon_m}{\epsilon_v}$

Capacitance of a Capacitor & its dependencies

~~$C = A\epsilon_0\epsilon$~~

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

$$C_m = \frac{A\epsilon_m}{d} = \frac{A\epsilon_r\epsilon_0}{d}$$

$$C_m = \epsilon_r C_v$$

$$\downarrow$$

$$\boxed{\epsilon_r = \frac{C_m}{C_v}}$$

$$\boxed{C_m > C_v}$$

$$C = \frac{A\epsilon_0}{d} \quad \left(\epsilon_0 = \frac{1}{4\pi k}\right)$$

$$\boxed{C = \frac{A}{4\pi k d}}$$

$C \propto A$

$C \propto \epsilon_m$ $C \propto \epsilon_r$ $C \propto \epsilon_0$

$C \propto 1/d$

Scanned by CamScanner

Energy stored in a capacitor:

$U = \frac{1}{2} QV$ or, $U = \frac{1}{2} \frac{Q^2}{C}$

$\Delta U = \frac{1}{2} CV^2$ or, $U = \frac{1}{2} \epsilon_0 E^2 (Ad)$

$U = \frac{1}{2} \epsilon_0 E^2 (Vol)$

$U = \epsilon_m E^2 (Ad)$

$$\boxed{U_m = \frac{1}{2} \epsilon_0 \epsilon_r E^2 (Vol)}$$

If we put the medium → energy stored will be increases → mag q charges increases on each plate.

$U \propto Q^2$	$U \propto$ volume
$U \propto C$	$U \propto A$

$\boxed{U \propto V^2}$ (imp)

$U \propto E^2$

$U \propto \epsilon_m$ or $U \propto \epsilon_r$

If $\boxed{V_c = E_c d_c}$

If d_c → increases

V_c increases then battery discharges

during charging $\Delta V_{ckt} = V_s - V_c$

↳ V_c - increases

so ΔV - decreases

when capacitor is fully charged

$\Delta V_{circuit} = 0$