Date	Title	Page No.	Teacher's Sign/ Remarks
	1) charge and it's Properties		
	2) method of charging		
	3) Coulomb's law and superposition law		
	4) Application of Coulomb's law.		
	→ question of more than two charges.		
	→ question of electrostatic's and S.H.M		
	→ question of electrostatics and N.L.M		
9/9/19			
	5.) Electric field	47	
	6.) Electric field Intensity		
	7.) Application of $F = qE$		
	→ question of kinematics		
	→ Projectile motion		
	→ E due to point charge		
	→ superposition principal		
	7.) Electric dipole	73	
	→ E due to a dipole :-		
	8.) → Dipole moment :-		
	→ E at axis, equitorial axis, and also at some angle "θ"		
	→ question of dipole (···)	80	
	9.) Electric Potential energy	87	
	10.) Electric Potential or Potential	91	
	→ Electric Potential (V) due to Point charge or $V = q/4\pi\epsilon_0 r$		

1st Choice

Electromagnetism

Page No.
Date / /

- Electrostatic
  - → charge and electric field (electrostatic)
  - → Gauss law
  - → capacitor
- Electrodynamic
  - → Electric current
  - → magnetic effect of current
  - → Electro magnetic Induction
  - → Alternating current

Board → 50%
JEE → 30 to 35%

Electrostatic unit :→

Electro → Charge

static → something which does not change with time or something which is at rest.

charge → 1) charge is a fundamental property of any material or matter which is responsible for all electrical phenomena (electrical force)

- charge एक Hero है जो दिखता नहीं but इसकी acting दिखती है। इसलिए हम इसे super-hero भी कह सकते है

2.) Type of charge:-

i) Positive charge:-
ii) Negative charge

3.) Unit of charge is "coulomb"

4.) One coulomb is very big value of charge

~~KDC~~

$1\ mC = 10^{-3}\ C$ → (milli coulomb)

$1\ \mu C = 10^{-6} C$

$1\ nC = 10^{-9} C$

$1\ PC = 10^{-12} C$

5.) C.G.S unit of charge is esu.

$1\ C = 3 \times 10^{9}$ esu

6.) When there is a imbalance b/w no of proton and electron in a body we say that body acquire charge.

(बोले तो body hero बन गया)

lack of e^- ⇒ +ve charge.
excess of e^- → -ve charge.

* Properties of charge →

1) like charges repeal and unlike charges are attract each other.

← ⊖ ⊖ → Repeal

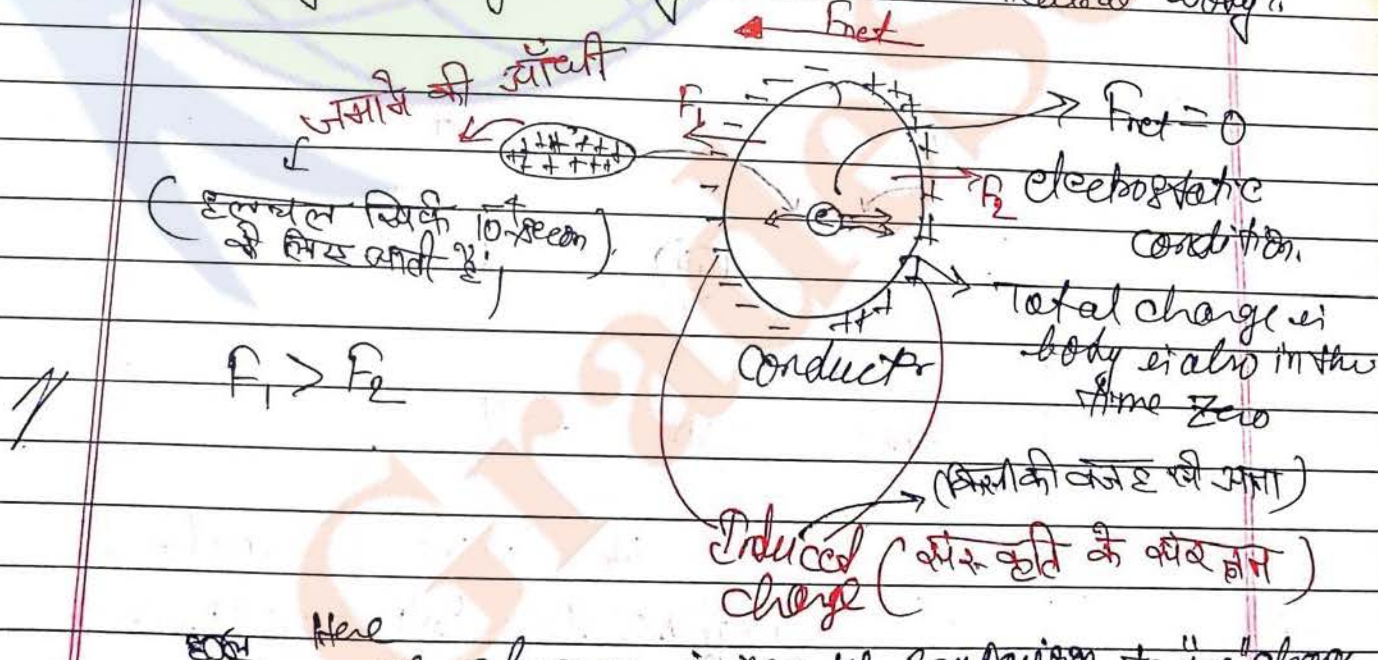
⊖ → ← ⊕ Attract

eg1 → A +vely charge body attract another conducting body then another body is

soln →

a) +ve charge
b) -ve charge
c) neutral (कोई charge नहीं है)

Q) why charge body attract neutral body?



Here -ve charge is near us comparison to +ve charge.

1st Choice

Ex 1.) A B Repeal
+ +

B C Attract
+ −

C D Repeal
− −

A D ? so Attraction
+ −

Sol/ⁿ
Concept:– Repulsion is the sure test for electrification (charge)

It always target on repulsion charge.

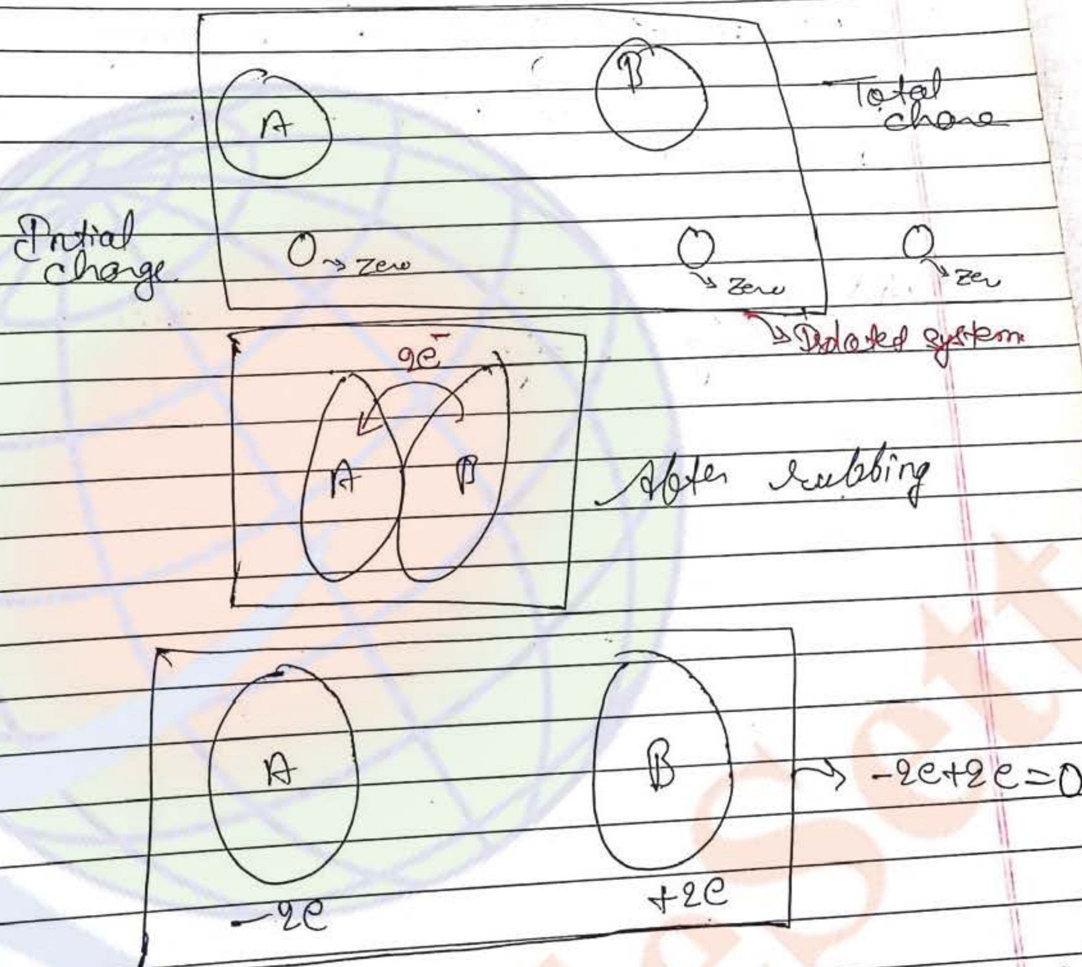
Ex 2.) A B Att

C D Repeal
+ +

A D = ?

Here more Information is requires to solve this Problem

2.) In an Isolated system total charge of the system remain conserved or constant



3.) charge is quantized.

Charge on any body is always Integral multiple of electronic charge ($e = 1.6\times10^{-19}$ C)

$Q = \pm ne$, $n = 1, 2, 3, \ldots$
$e = 1.6\times10^{-19}$ C

(8)

(ix) Is this ~~positive~~ charge $3.2 \times 10^{-21} C$ on a body is possible.

Sol No, because "n" is not a Integer.

$$3.2 \times 10^{-21} C = n \times 1.6 \times 10^{-19}$$

$$n = $$

(x) value of charge is Independent of speed of charge body.

1st Choice

Page No.
Date / /

Method of charging →

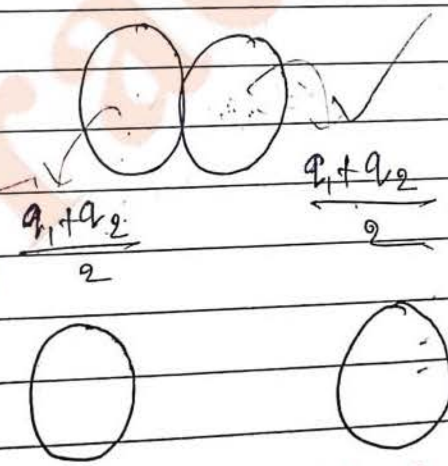
Contact method
Induction method

Friction method
Conduction method

1) Friction method :-
By this method equal and opposite charge come on both rubbed bodies.

II) conduction method :-
when two conductor in which one should be charge are broad in contact then equal sharing of charge take place b/w them.

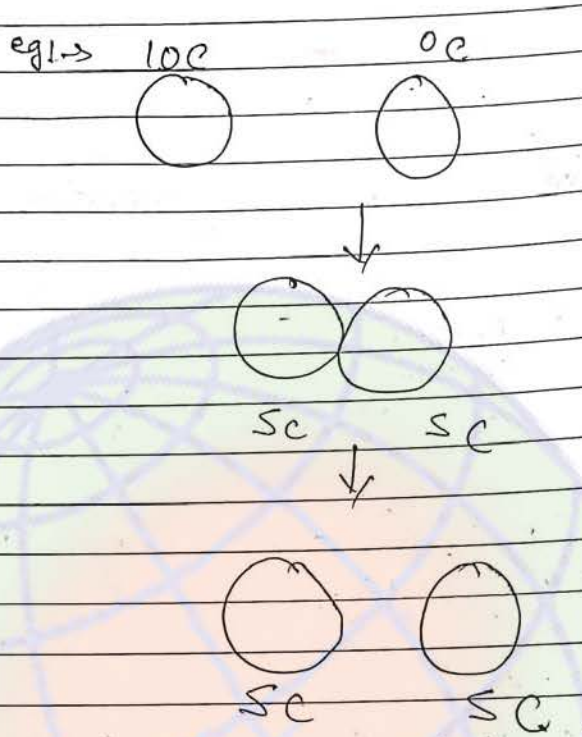
two Identical conducting sphere



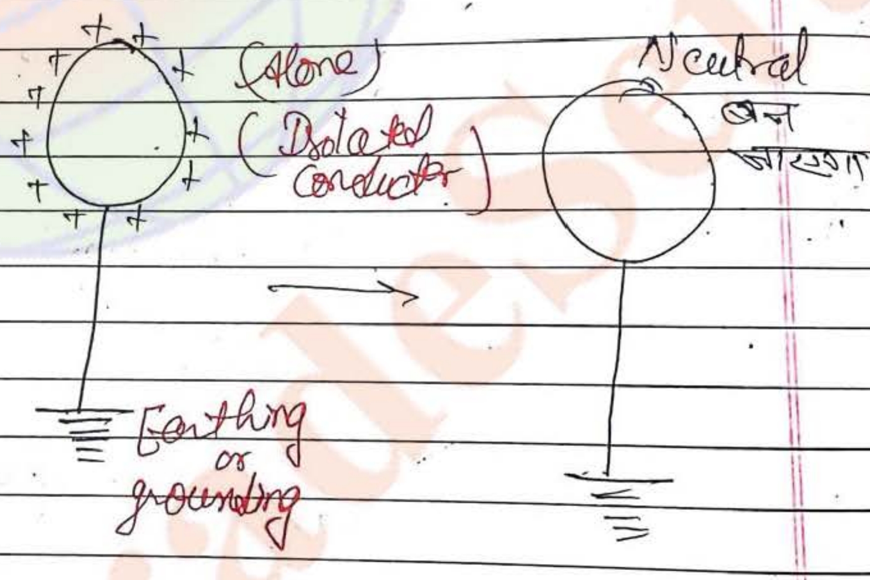
v.v.I

Here q_1, q_2 with sign

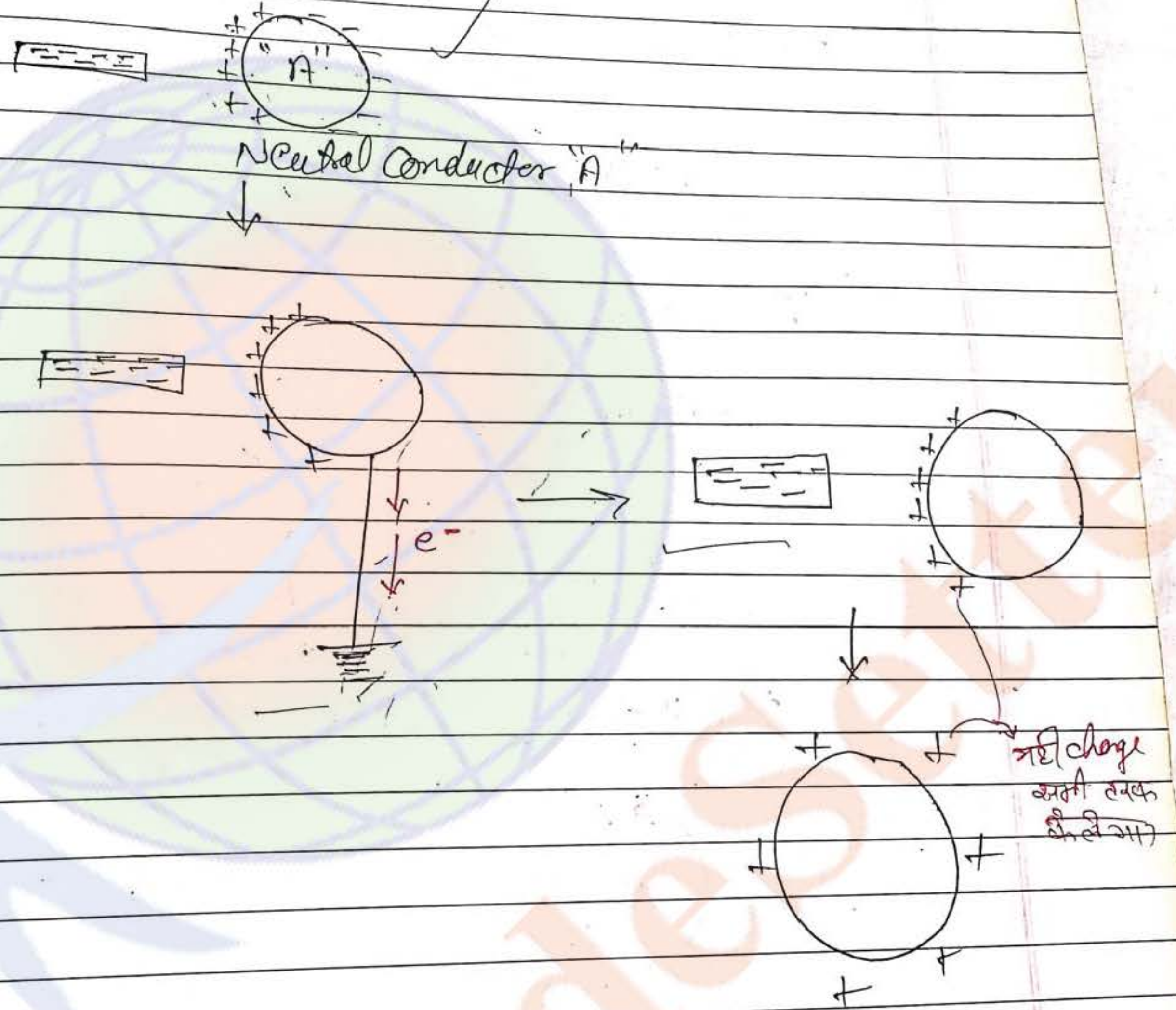
eg1 →



Notes → Earthing and Groundings —

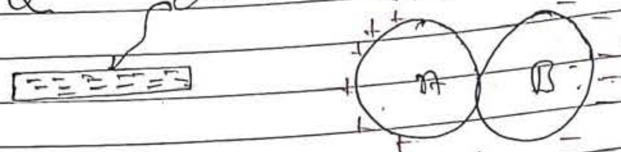


3) Induction method ⇒

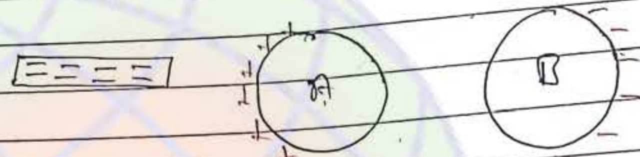


Ex1. Q charged room

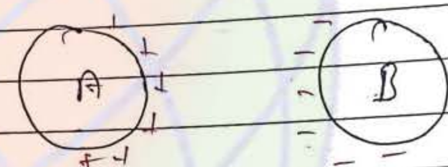
Step-1st



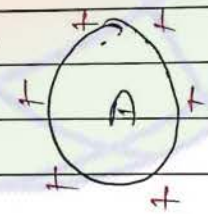
Step IInd -

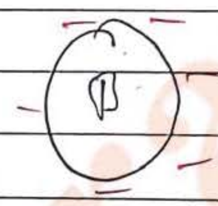


Step IIIrd



Step IVth





Determine charge on "A" and "B"

Coloumb law →

1) This law give the electrical force b/w two point charges.

q_1 vaccum q_2

2) This law is applicable only for point charges. but Hence, to Integral calculus because with the ~~lot~~ help of that calculus we can determined force b/w large charge body.

3.) Physically point charge does not exist in nature actually it is electrostatic behavior which can be shown by any body on particular condition.

vaccum

Colomb law

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

F = electric force b/w q_1 and q_2

r = seperation b/w point charges.

ε_0 = electrical Permitivity of vaccum

→ Permit mean's Permission.

when q_1 and q_2 are in a medium rather than in vaccum than Permitivity get change thus force b/w charges get change.

will not or want

1st Choice

Now medium

q_1 • - - - - - - - • q_2

ϵ_m = electrical permittivity of medium

$$\boxed{F_{medium} = \frac{1}{4\pi\epsilon_m} \frac{q_1 q_2}{r^2}}$$

examiner की चालाकी → examiner will not give

"ϵ_m" Instead of ϵ_m he given ϵ_r or K of medium.

Here ϵ_r or K relative permittivity of medium or Di-electric constant of medium

So,

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

So,

$$\epsilon_m = K \times \epsilon_0 \text{ or } \epsilon_r \times \epsilon_0$$

So,

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

Note: →

$$1 \leq K \leq \infty$$

K = 1 ⇒ In vaccum

K = ∞ ⇒ In metal or conductor

Note →

4) In vaccum force b/w charge particle is maximum

Note

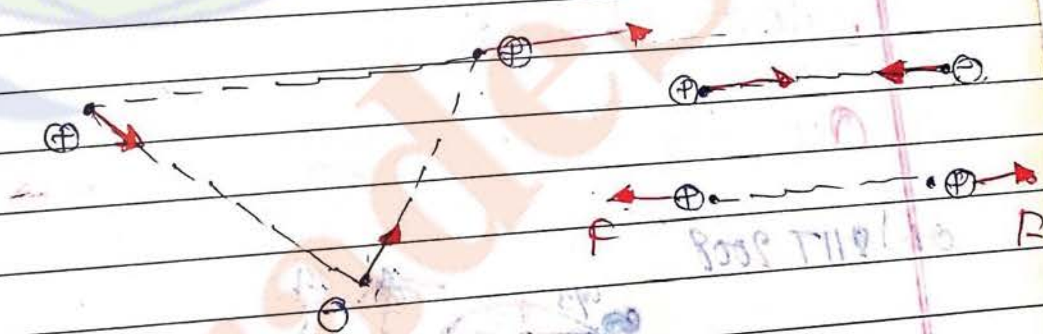
$$\varepsilon_0 = 8.85 \times 10^{-12} C^2 m^{-2} N^{-1}$$

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 N m^2 C^{-2}$$

eg1 → 1 cb •——— 1 m ———• 1 cb

$$F = 9 \times 10^9 N$$

5) Direction of force is along the line joining point charges.



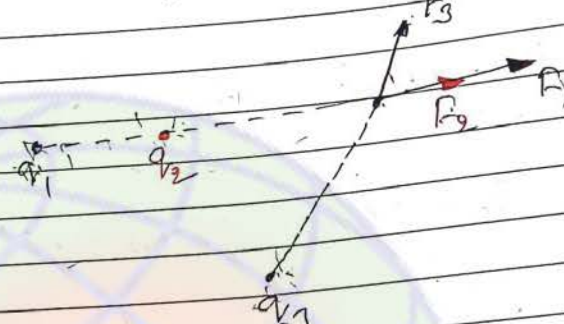
6) Electric force is a conservative force

7) Electric force follows superposition principle.

Ra.

1st Choice

Superposition Principle →



1) Force b/w two charge particle does not change due to presence of any charge nearby two charges, but net force on any charge is vector of all the individual force acted by individual force.

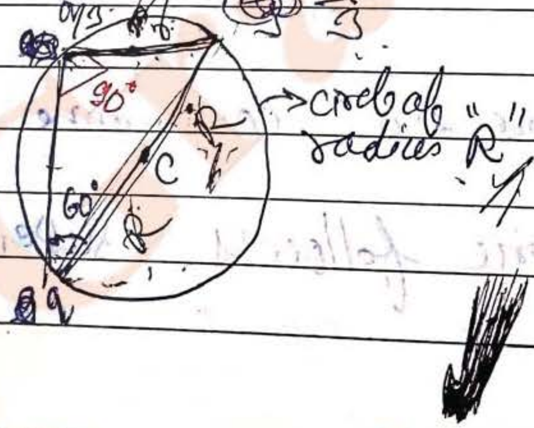
Note: यहाँ पर vector किया जाता है ... इस लिए ध्यान देंगे।

$$\boxed{F_{net} = F_1 + F_2 + F_3}$$

Application ! →

1) Question of two charges only. →

Q4) IIT 2008



Determine the force b/w $q/3$ and $-\frac{2q}{3}$ charge.

Sol.

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

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{3} \times \frac{2q}{3}\right)\frac{1}{r^2}$$

$$\sin 60 = \frac{r}{2R}$$

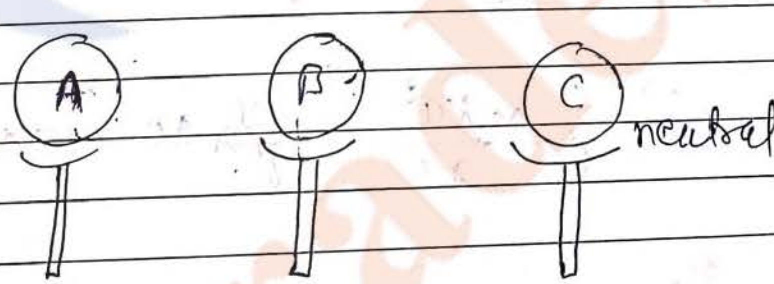
$$r = \sqrt{3}R$$

Now

$$\Rightarrow \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{3} \times \frac{2q}{3}\right)\frac{1}{(\sqrt{3}R)^2}$$

$$\Rightarrow 9\times10^9 \, \frac{2q^2}{9} \times \frac{1}{3R^2}$$

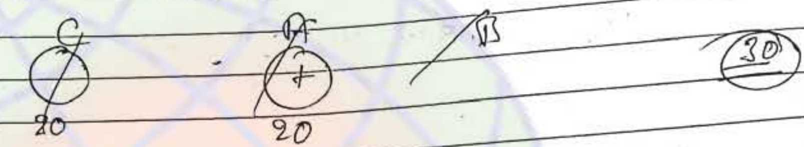
Ex 2.

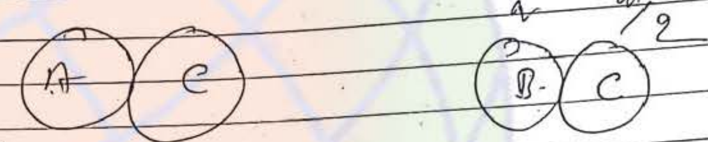


A, B and "C" are three Identical metallic sphere. "A" and "B" have Identical charge and the force b/w "A" and "B" is 10N

Now sphere "C" is 1st touch to A and Now to "B". Now determine the new force on A and B

Sol^n





$$\frac{q+0}{2} \qquad \frac{q+0}{2}$$

$$\frac{q}{2} \qquad \frac{q}{2}$$

$$\frac{q+\frac{q}{2}}{2} \qquad \frac{q+\frac{q}{2}}{2}$$

$$\Rightarrow \frac{3q}{4}$$

$$F = k\,\frac{3q}{4} \times \frac{q}{2} \times \frac{1}{r^2}$$

$$\Rightarrow \frac{3}{8} \times \frac{kq^2}{r^2} = \frac{3}{8} \times 40 = 15\,N$$

Ex 3)

Certain amount of charge say x-coulomb is taken out from a sphere and given to a small neutral sphere. for what value of "x" force b/w two sphere is maximum

Sol/n

$Q-x$ $\qquad\qquad$ x

$$F = \frac{k(Q-x)(x)}{r^2}$$

$$F \propto q(x) = (Q-x)(x)$$

diff

$$\frac{d(Qx - x^2)}{dx} = 0$$

$$Q - 2x = 0$$

$$x = \frac{Q}{2}$$

1st Choice

Application of Coulomb's law

Question of more than two charges →

Q1)

$$\overset{-q}{\bullet}\xleftarrow{\ a\ }\xrightarrow{}\overset{+4q}{\bullet}\xleftarrow{\ a\ }\xrightarrow{}\overset{2q}{\bullet}\xleftarrow{\ a\ }\xrightarrow{}\overset{P}{\bullet}$$

F_2 F_1 F_3 $P(-)$

What charge should be placed at point "P" so that net force on 4q becomes zero

Sol)

$$F_1 = \frac{K\,4q^2}{a^2} \leftarrow \frac{K(q)(4q)}{a^2}$$

$$F_2 = \frac{K\,8q^2}{a^2} \leftarrow \frac{K(4q)(2q)}{a^2}$$

$$\frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{(r)^2}$$

$$\Rightarrow F_{net} = \frac{K \times 12q^2}{a^2} \text{ of } F_1 \text{ and } F_2$$

$$\frac{(2a)^2}{= 4a^2}$$

Now we take (by direction method) "-ve" then,

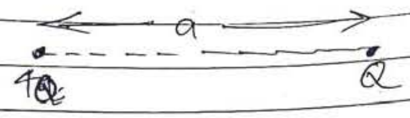
$$F_3 = \frac{K \times 4q \times Q}{4a^2}$$

$$\frac{K \times 4q \times Q}{4a^2} = \frac{K \times 12q^2}{a^2}$$

$$Q = -12q$$

"-ve" इसलिए क्योंकि ही consider किया है और logical है यहाँ "-ve" charge ही आएगा

Ex 2.



what charge should be place and where it should be placed so that whole system of three charge comes in equillibrium

Sol^n

Concept → System equillibrium mean's that net force on each charge of the system is zero.

$\frac{K \times 4Q^2}{a^2}$

"q" should be "-ve"

$$\frac{K \times 4Q^2}{a^2} = \frac{K \times 4Q \times q}{x^2} \quad (F_{net} \text{ on } 4Q = 0) \quad \text{--- (1)}$$

$$\frac{K \times 4\cancel{Q} \times \cancel{q}}{x^2} = \frac{K\cancel{Q} \times \cancel{q}}{(a-x)^2} \quad (F_{net} \text{ on "q"} = 0) \quad \text{--- (2)}$$

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

$$2a - 2x = x$$

$$2a = 3x$$

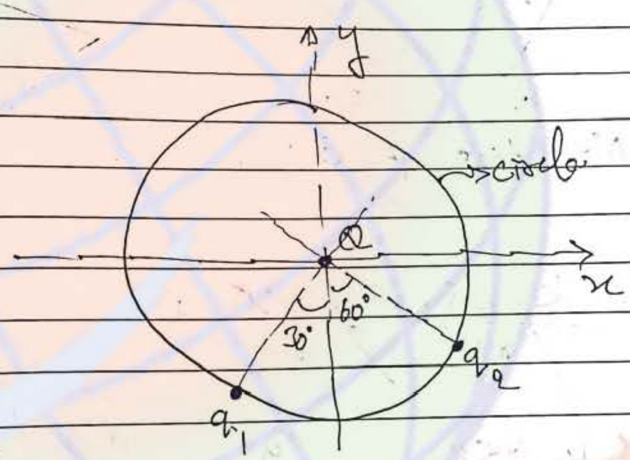
$x = \frac{2a}{3}$

Put x in eq (1)

$$\frac{K \times Q \cdot 4Q^2}{a^2} = \frac{K \times 4Q \times q}{\left(\frac{2a}{3}\right)^2}$$

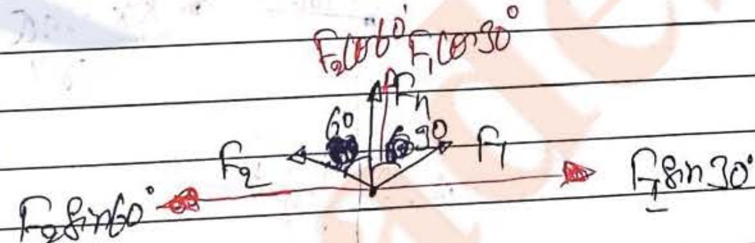
$$q = -\frac{4q}{9}$$

Ex 3.



Determine $\frac{q_1}{q_2}$ if net force on "Q" is in verticle direction

Soln



$F_1 = \frac{K q_1 Q}{R^2}$, $F_2 = \frac{K q_2 Q}{R^2}$

D.P.P. No 1 Q No. 1 to 9

Sheet 2 Ex 1,6,4,3,5,

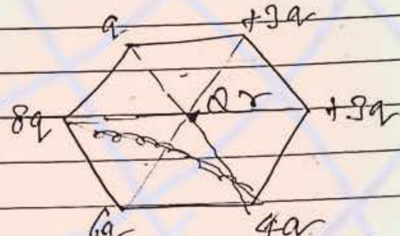
Page No. 99

as F_{net} is along y

$\therefore F_2 \sin 60 = F_1 \sin 30$

$F_2\sqrt{3} = F_1$

Ex 4)

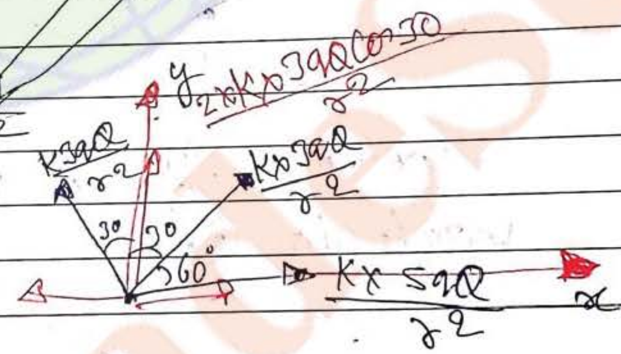


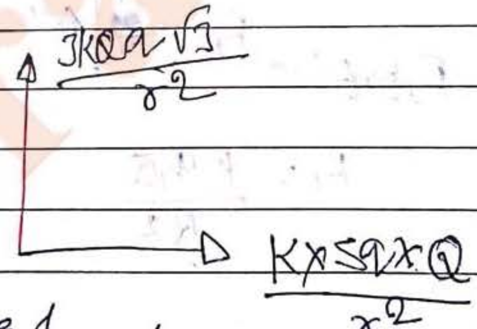
Net force of Q = ?

Soln

$F = \frac{k\,6qQ}{r^2} + \frac{k\,4qQ}{r^2} +$

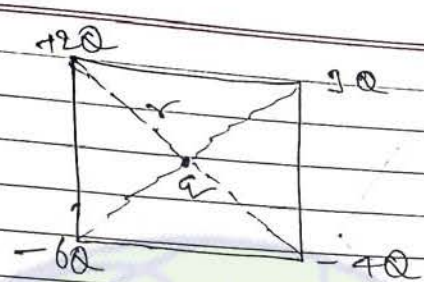
$y\ \frac{k\,25q}{r^2}$





find resultant and get constant

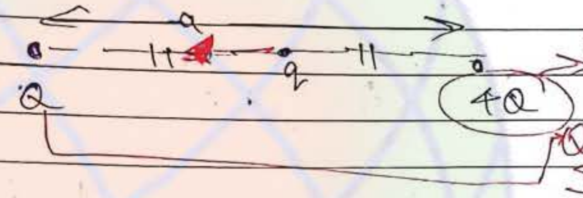
Es.



F_{net} on $q = ?$

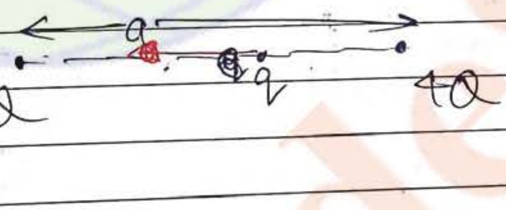
Sol^n

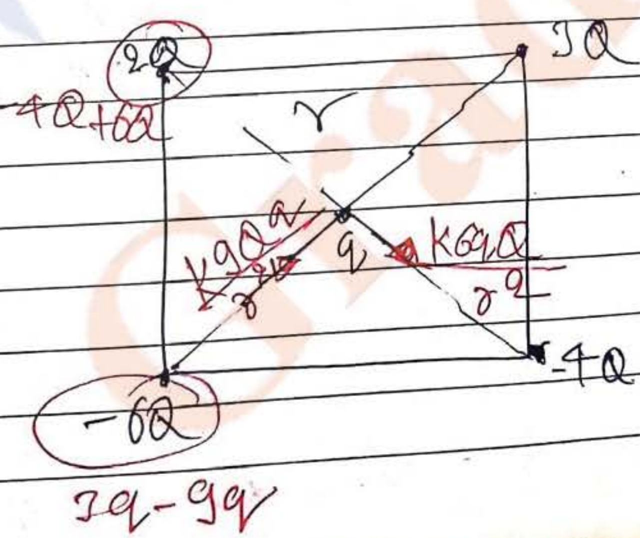
Concept:->



then

$$F = \frac{k\, q\, 3Q}{a^2}$$



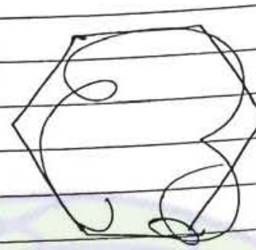


so,

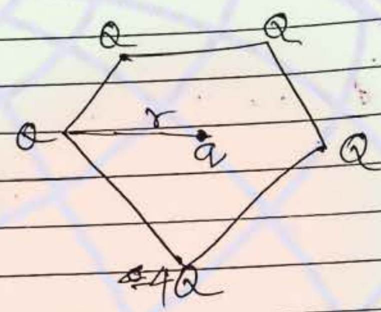
$$F_{net} = \frac{kQ \times q}{r^2}\sqrt{6^2+9^2}$$

3q - 9q

Sol)



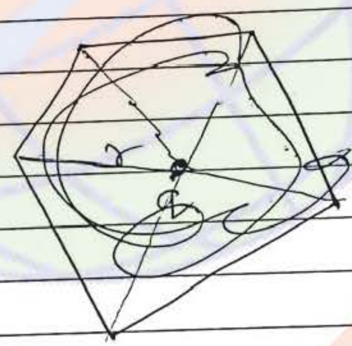
Sol)



Regular Pentagon

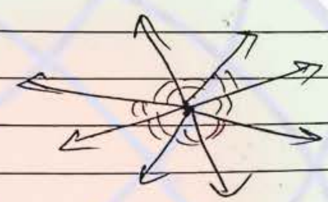
Force on q = ?

Sol)



Concept 1 ⇒

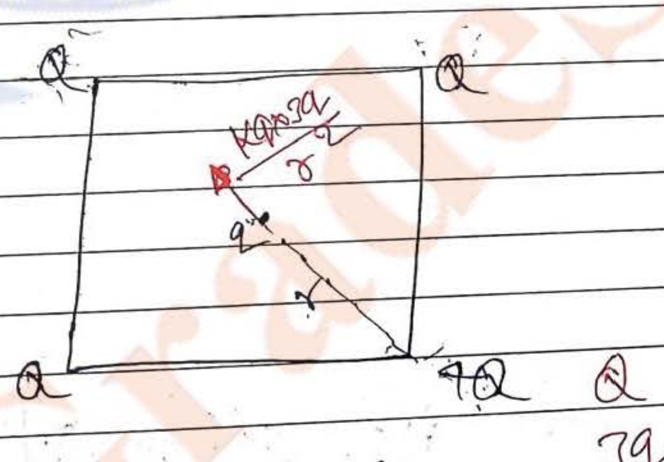
1) n-vector each of equal (same) magnitude arrange symmetrically (equal angle) then the resultant of such vector's is zero.



n-vector each of same magnit

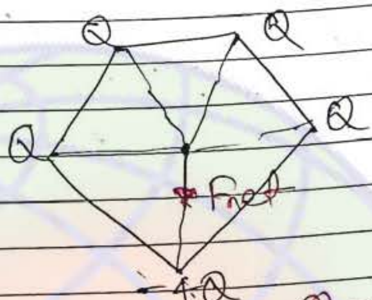
II) when in regular polygon charges of equal magnitude and same sign placed at each corner then resultant force on charge placed at centre of polygon is zero.

eg1 ⇒



$F = \frac{KQ3q}{r^2}$ (By काटना trick or तरीका)

for this method



$Q = 5Q$

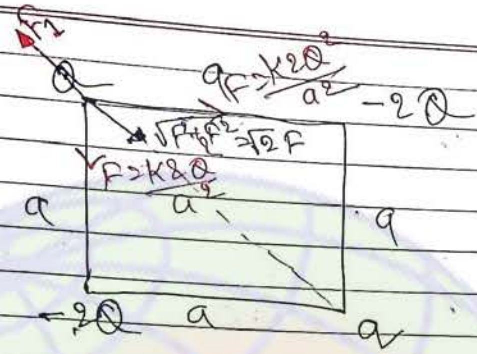
$$F_{net} = \frac{K\,5Q^2}{r^2}$$

यह trick is applicable when regular polygon is given and ~~acc~~ except at one corner charges are identical at each corner

यदि कोई charge नहीं होता तो +Q और -Q फिट कर सकते हो

$$Q + (-Q) = 0$$

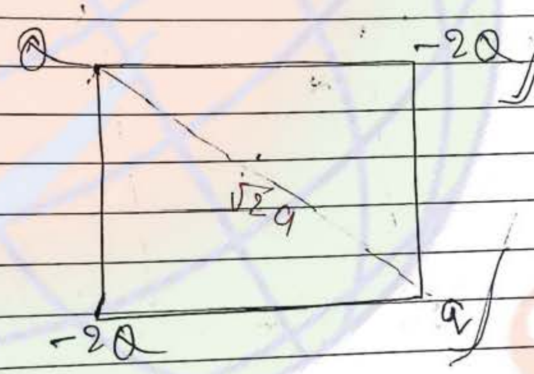
Q:7)



Square.

Determine $\frac{q}{Q}$ if F_{net} on "Q" is equal to zero.

So)



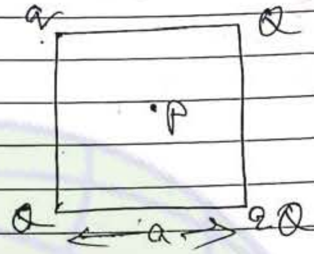
F_{net} on $Q = 0$

$F_1 = \sqrt{2} F$

$$\frac{KQq}{2a^2} = \sqrt{2}\,\frac{K \times 2Q^2}{a^2}$$

$$\frac{q}{Q} = 4\sqrt{2}$$

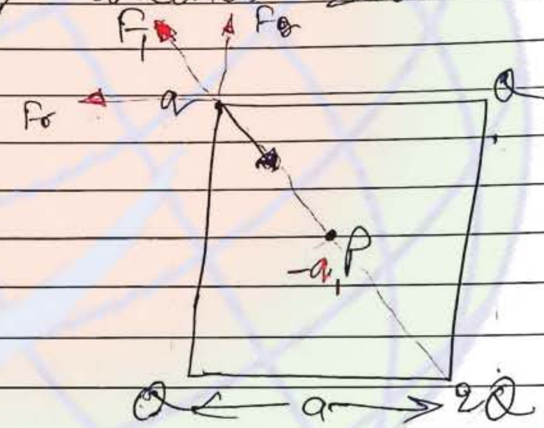
Q8.)



Square of side = a

what charge should be placed at Point "P" so that net force on "q" becomes zero.

Sol



$F_1 = \frac{KQq}{a^2}$

$\sqrt{2}F$ F $F_{net} = F_1 + \sqrt{2}F$

$$\boxed{-\frac{(1+\sqrt{2})}{2}Q}$$ Ans

ये ही मेरा मुद्दा था

1st Choice

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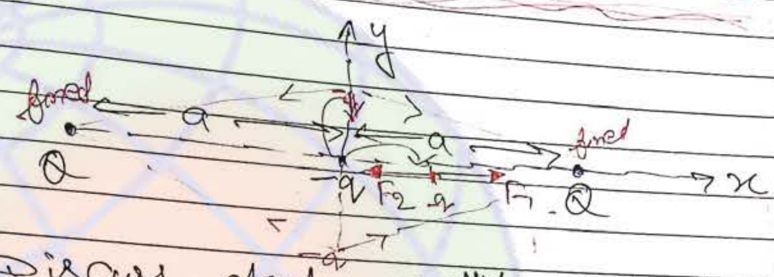
Date / /

Q5) Question of electrostatic and SHM →

gravity neglect



Discuss about equillibrium of "q" along x-axis as well as along y-axis.

Sol^n

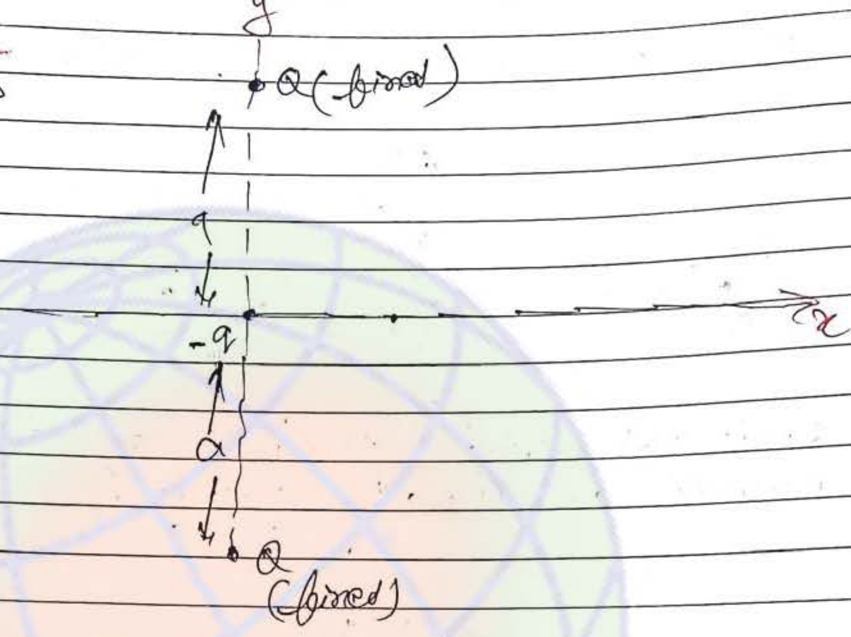
$F_1 > F_2$

F_{net} →

Along x-axis unstable

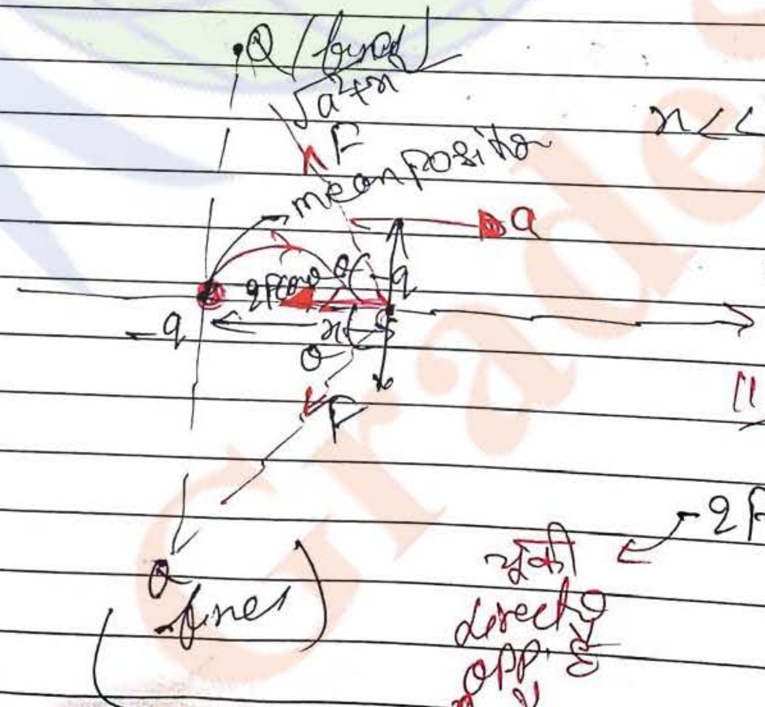
But

In along y-axis it is stable.



"q" charge is slightly displaced along x-axis and then released. Determine time period of its oscillation after it release.

Sol^n.



$x <<<<<<<<< a$

1) $a = -\omega^2 x$

II) Newton IInd law

$-2F\cos\alpha = ma_c$

यहाँ direction opp है acc का

$$\Rightarrow \frac{-2KQ\times a}{a^2+x^2} \times \frac{x}{\sqrt{a^2+x^2}} = ma_c$$

$$a_c = \frac{-2KQ\times a}{(a^2+x^2)^{3/2}} \cdot \frac{x}{m}$$

$$\boxed{a_c = \frac{-2KQ\times a}{ma^3}\, x}$$

SHM are proved

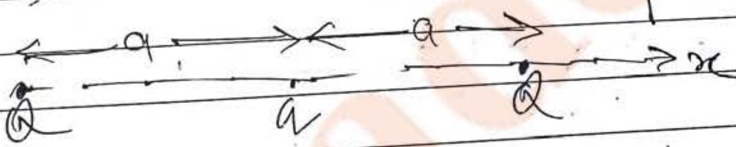
$$T = \frac{2\pi}{\omega}$$

$$\omega = \sqrt{\frac{2KQ\times a}{ma^3}}$$

$$\cos\theta = \frac{x}{\sqrt{a^2+x^2}}$$

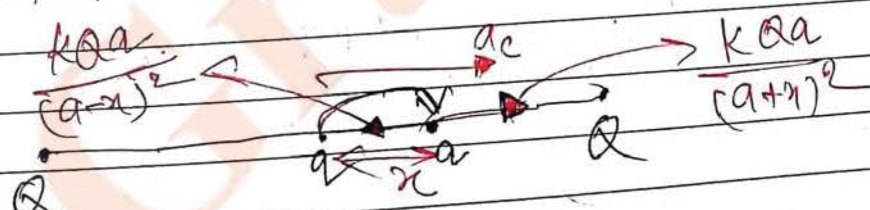
$$F = \frac{K\times Q\times a}{a^2+x^2}$$

Q.2



Repeat the same Question as above

Sol



$$\frac{-kQa}{(a-x)^2} + \frac{kQxa}{(a+x)^2} = ma$$

जिस force का direction की तरफ होता है उसी "+ve" से लिखे बाकी को "-ve" से लिखे

$$\frac{-kQxa}{a^2\left(1-\frac{x}{a}\right)^2} + \frac{kQa}{a^2\left(1+\frac{x}{a}\right)^2} = ma_c$$

$$\frac{-kQxa}{a^2}\left[\left(1-\frac{x}{a}\right)^{2} - \left(1+\frac{x}{a}\right)^{-2}\right] = ma_c$$

$$\frac{-kQa}{a^2}\left[1+\frac{2x}{a} - \left(1-\frac{2x}{a}\right)\right] = ma_c$$

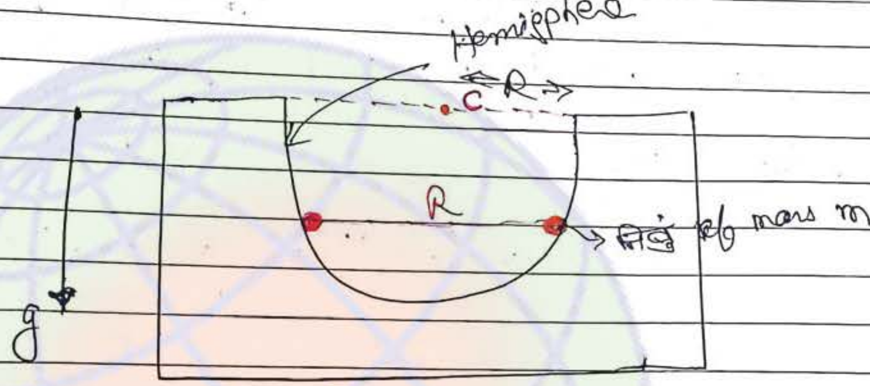
$$-\frac{4kQ\,xa\,x}{a^3} = ma_c$$

$$\boxed{a_c = \frac{-4kQxa}{ma^3}\,x}$$

1st Choice

Question's of electrostatic and NLM →

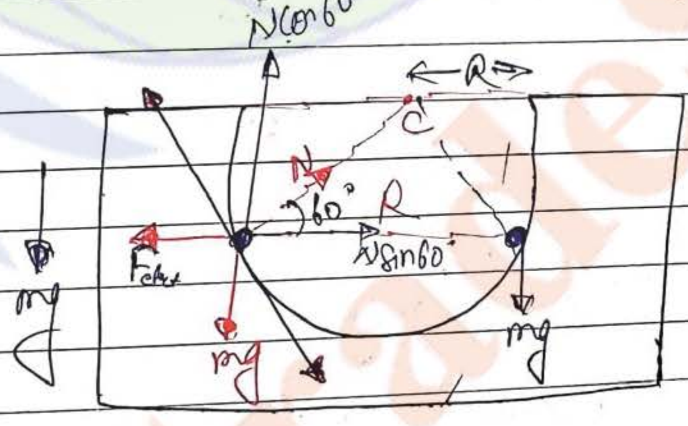
Que)



Hemisphe of radius "R" friction is neglected

lemons is lying on the surface of Hemisphere in equillibrium condition both lemon have same charge determine this charge

Sol)



$\Sigma F_V = 0$ vertical

$\Sigma F_H = 0$

$\tau_{net} = 0$

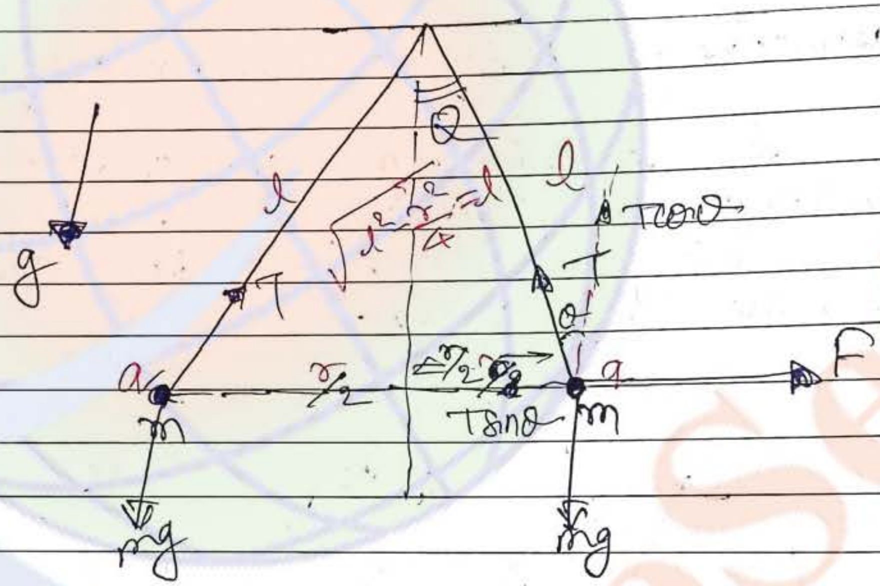
$N \sin 60 = mg$

$N \cos 60 = \frac{1}{4\pi\epsilon_0} \frac{q^2}{R^2}$

$\cot 60 = \frac{q^2}{4\pi\epsilon_0 mg R^2}$

Exp.) Two Identical ball having same mass and same charge are substended by two Identical ~~st~~ silk from the point of a ~~cei~~ siling.
If the equilibrium seperate b/w this ball is "r" and $l \geq\geq\geq r$ then determine "q" charge on the ball.

Sol.)



$$T\cos\theta = mg$$

$$T\sin\theta = \frac{Kq^2}{r^2}$$

$$\tan\theta = \frac{Kq^2}{mgr^2}$$

$$\tan\theta = \frac{r}{2l}$$

$$\frac{r}{2l} = \frac{kq^2}{mgr^2}$$

$$\boxed{q^2 = \frac{mg}{2kl}r^3}$$

H.W

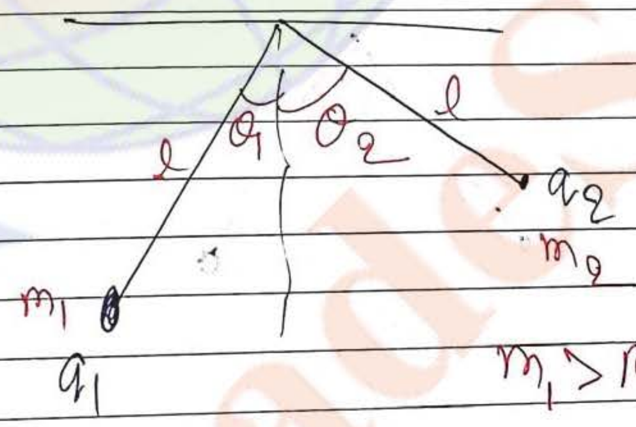
$\frac{dq}{dt}$ = charge leak rate.

$\frac{dr}{dt}$ = ?

Relative velocity — Irodov Question

H.C.V

Concept



$m_1 > m_2$ (Possible only)

[illegible]

1st Choice

Ex2 2, 11, 3, 5, 1
Ex1 = 2, 7
D.P.P.S no = 2 (1 to 6)

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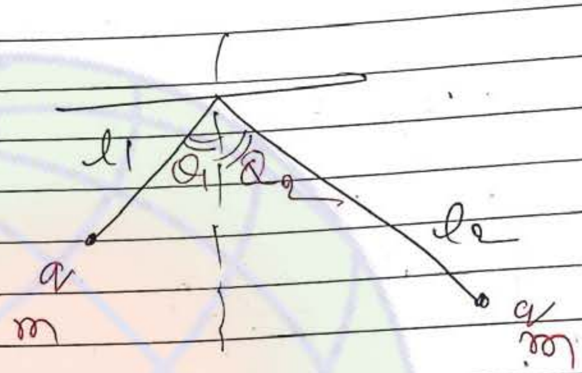
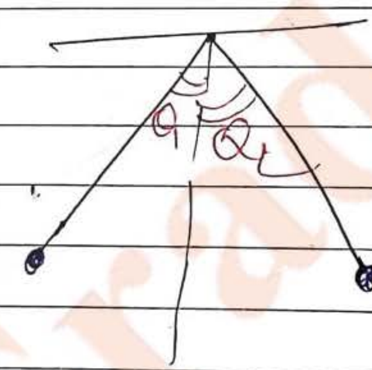
Concept



$l_2 > l_1$
mass are same
charge are same

Note
when $l_1 = l_2$ and mass of both ball is same then only $\theta_1 = \theta_2$

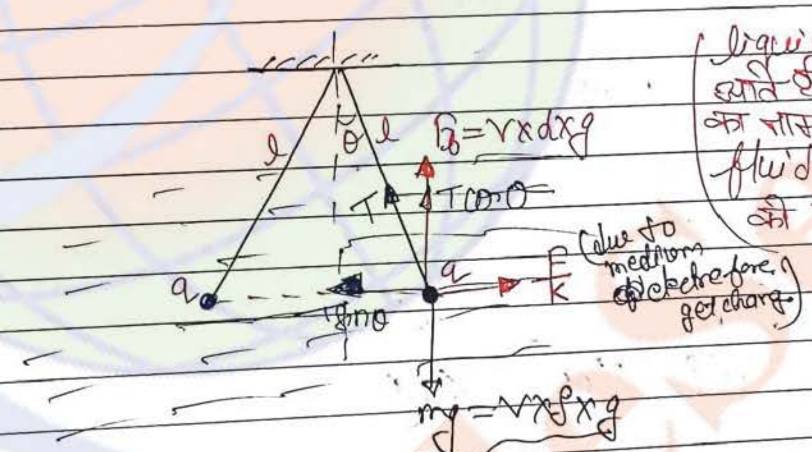


Q.) Hole setup of ~~previous question in~~ suffered in पाताल लोक in liquid medium

~~They~~ Their also angle b/w both string remain as it was previously. determine di-electric constant of liquid in पाताल लोक।

ρ = density of ball
d = density of liquid

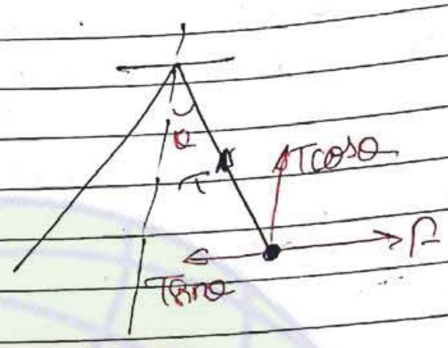
So/n



(liquid का नाम आते ही या fluid का नाम आते ही fluid mechanics को याद करें)

$$T\cos\theta + F_b = mg$$
$$T\cos\theta = mg - F_b$$
$$T\cos\theta = V\rho g - Vdg$$
$$T\sin\theta = \frac{F}{K}$$
$$\boxed{\tan\theta = \frac{F}{K[\rho - d]Vg}}$$

कहाँ गी पाताल लोक की है।



$T\cos\theta = mg$

$T\sin\theta = F$

$\tan\theta = \frac{F}{mg}$

$\tan\theta = \frac{F}{V\rho g}$

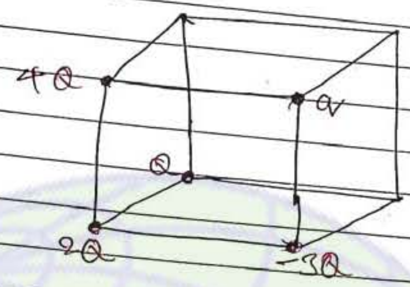
कहानी खत्म की

$$\frac{\cancel{F}}{K(\rho-d)\cancel{V}\cancel{g}} = \frac{\cancel{F}}{\cancel{V}\rho\cancel{g}}$$

$$\boxed{K = \frac{\rho}{\rho-d}}$$

$d \rightarrow$ (density of liquid)

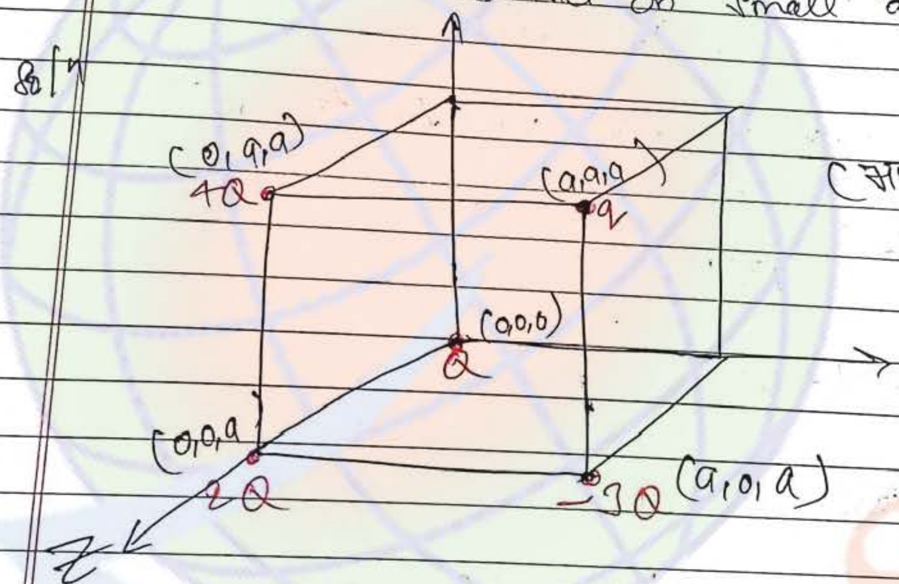
Q.)



Cube of side "a"

determine Force on small "q"

Sol



(समानक शरीर डरावना question है)

This question is in 3-D and very unsymmetric. If we solve this question by making force diagram on the paper then हम चक्कर आ सकते हैं।

To solve such question we will use vector approach :-

Sol.

vector's form of coulomb law :-

$q_1 \xrightarrow{\ r\ } q_2$ (सुई वहाँ होगी जिस पर "F" निकालना है)

$\vec{F}_{21}$ = Force on "q_2" due to "q_1"

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

$\vec{r}$ = Position vector of q_2 w.r.t. q_1
(सही concept)

$\hat{r}$ = Unit vector in the direction of $\vec{r}$

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

$$|\vec{r}| = r$$

$$\boxed{\vec{F}_2 = \frac{k q_1 q_2 \, \vec{r}}{|\vec{r}|^3}}$$

Put q_1, q_2 always with sign

नोट → In all vector formula's Put charge value with sign.

This formula gives magnitude as well as direction of force without any ~~[illegible]~~ [illegible] में दिमाग।

(x_1, y_1, z_1) — (x_2, y_2, z_2)

$(x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$

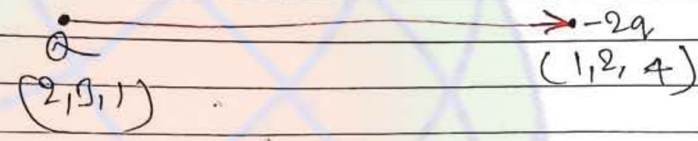
Q.

Q • (2, 3, 1)

• −2q (1, 2, 4)

Determine x, y and z component of force on "−2q".

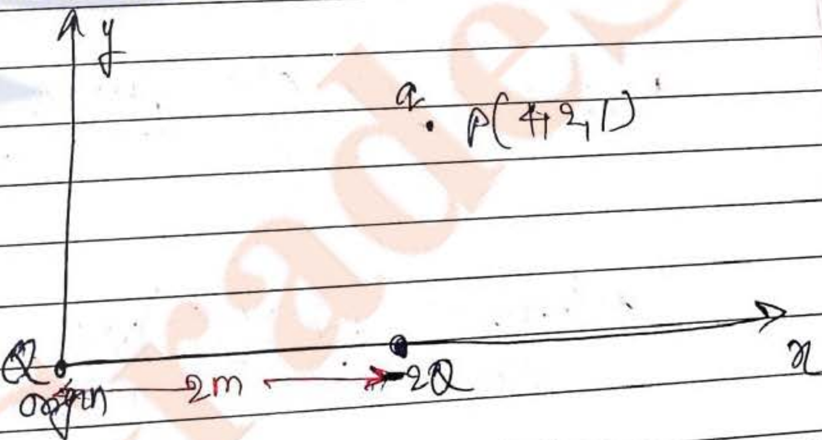
Sol:



$$\vec{F_1} = \frac{k(Q)(-2q)(-\hat{i} - \hat{j} + 3\hat{k})}{11\sqrt{11}}$$

$$\vec{F_1} = \frac{+kQ\,2q}{11\sqrt{11}}\hat{i} + \frac{kQ \times 2q\,\hat{j}}{11\sqrt{11}} - \frac{6Qq\,\hat{k}}{11\sqrt{11}}$$

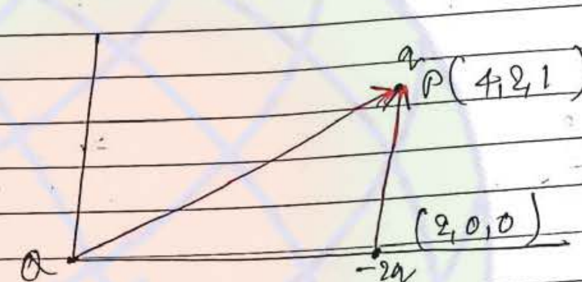
Q.



What charge should be placed at origin (O) so that x-component of force on "q" becomes zero.

80/14

$$\vec{F}_1 = \frac{K(q)(-2q)}{27}\left(2\hat{i}+2\hat{j}+\hat{k}\right)$$



$$F_2 = \frac{K(q)(Q_1)\left[4\hat{i}+2\hat{j}+\hat{k}\right]}{21\sqrt{21}}$$

$$F_{net} = \vec{F}_1 + \vec{F}_2$$

$$\vec{F}_{net} = \left[\frac{K(-4Q)q}{27} + \frac{Kq(Q_1)\times 4}{21\sqrt{21}}\right]\hat{i} + [\ ]\hat{j} + [\ ]\hat{k}$$

$$\frac{K(-4Q)q}{27} + \frac{Kq(Q_1)\times 4}{21\sqrt{21}} = 0$$

$$q = \frac{7\sqrt{21}\,Q}{9}$$

whenever examiner give question of 3-D and asking about x, y, z component of function use vector approach to solve the question.

When examiner gives very complicated unsymmetric 3D problem then this method will be very ~~bet~~ benificial to us.

Electric field

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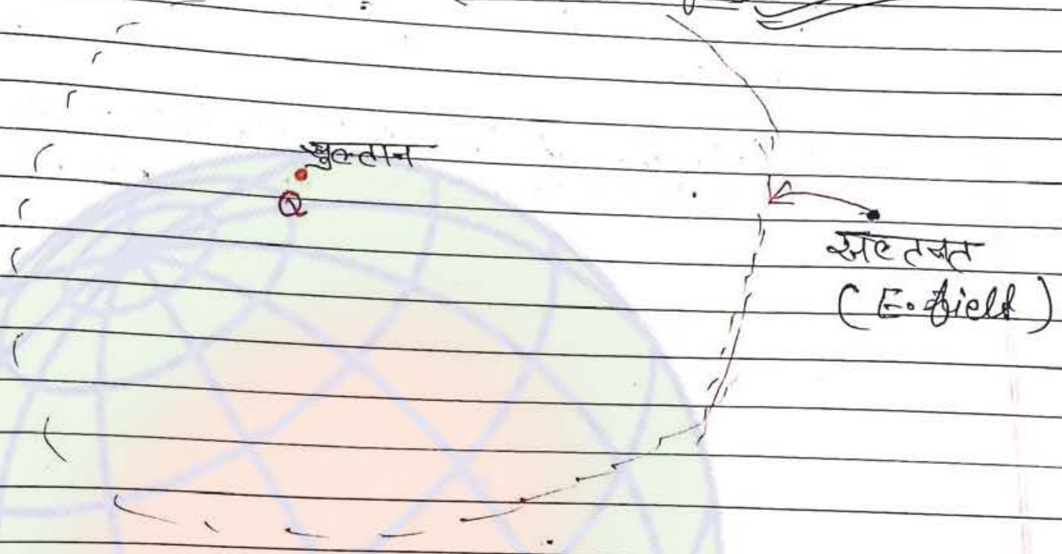
→ It is the region(इलाका) in which the charge body experience electric force

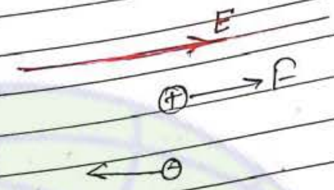


1) Every charge body, body createte or produce electric field just like (सुलतान)

II) Electric is a action at a distance force that mean's ~~to applied~~ no need to touch body to applied force.

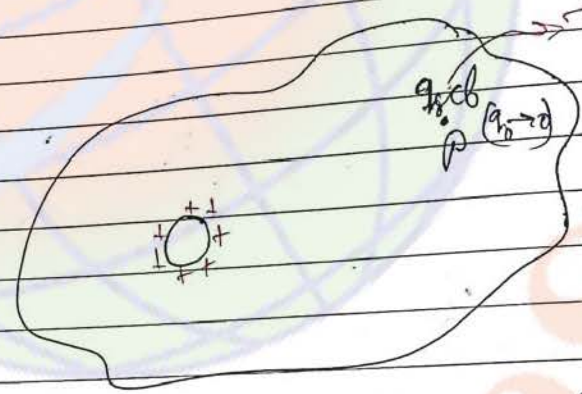
(Q create E.field and then this E.field ~~produce~~ apply force on q.)

(iii)



Direction of force on the charge is in the direction of electric field Intensity whereas direction of "-ve" charge is opposite to the direction of E (electric field).

(iii) Determination of "E" due to any [illegible]



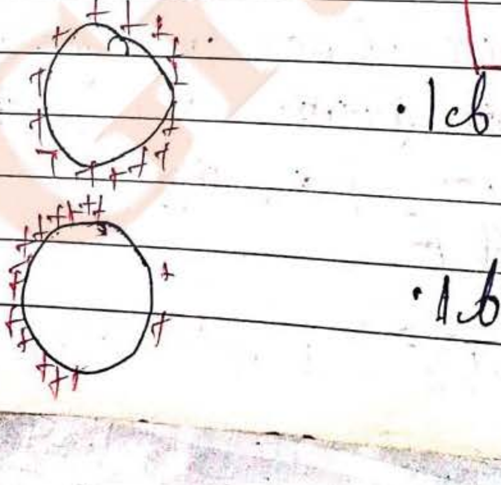
→ Test charge ([illegible]) because its Induction effect is very small.

F ⇒ force on q_0

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

$$\boxed{\begin{aligned} q_0 C &\to F \\ 1 C &\to \frac{F}{q_0} \end{aligned}}$$

चूंकी



18/4/2019

1st Choice

Application of formula $F = qE$

(*) Question of kinematics →

I)
$S = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$
$v = u + at$
+ Projectile motion.

II) Projectile motion

III) If in a (स्थान + क्षेत्र) Region magnitude as well as direction of $\vec{E}$ is same at each point such क्षेत्र is known as Uniform electric field.

Ques 1.) Two charge particle "A" and "B" have mass but their charges are "Q" and "4Q". These two particles are releases one by one in same uniform electric field (released from rest)
In time t_1 distance travelled by "A" is equal to distance travel by "B" in time t_2. Determine $\frac{t_1}{t_2}$?

Sol

(A) $\qquad$ (B) $\qquad (u=0)$

$q \qquad 4q$

$t_1 \qquad t_2$

$F = qE \qquad F = 4qE$

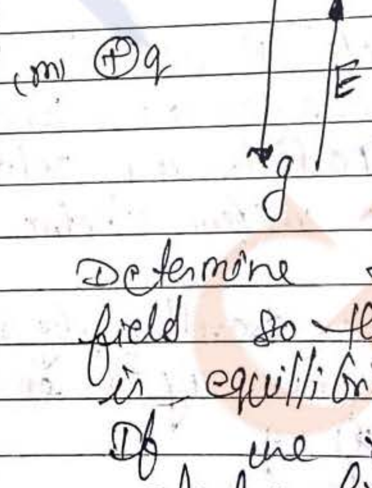
$a = \frac{qE}{m} \qquad a = \frac{4qE}{m}$

$$\frac{1}{2} \times \frac{qE}{m} \times t_1^2 = \frac{1}{2} \times \frac{4qE}{m} \times t_2^2$$

$$\frac{t_1}{t_2} = \frac{2}{1} = 2$$

(Attention ⇒ यहाँ भी charge दिया हुआ है जिसकी सहायता से पहले Force ($F = qE$) निकालिए और acc^n ($F = ma$) से निकाल लीजिए और फिर $S = ut + \frac{1}{2}at^2$ की equation को solve कर लीजिए।)

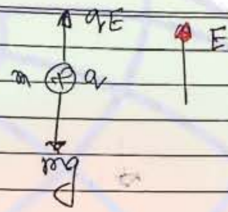
eg.)



Determine the value of electric field so that charge ball remain in equilibrium in air.
If we reverse the direction of electric field. Determine the acc^n of charge particle.

KV | Concept नहीं छूटी प्रश्न अलग हो जायेगा।

Sol i)

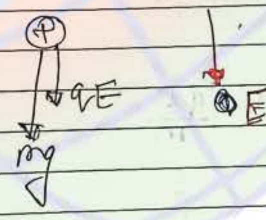


(नोट करें) — जिस direction में E है उसी direction में "+ve" charge move करता है। It means direction of force on +ve charge is in the direction of electric field intensity (E)

$$qE = mg$$

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

ii)



$$F_{net} = mg + qE$$

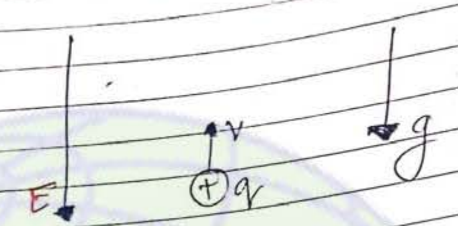
$$= mg + q \times \frac{mg}{q}$$

$$= 2mg$$

$$a = \frac{F_{net}}{m} = \frac{2mg}{m} = 2g$$

नोट: जो Particle पर the charge Particle पर नीचे की direction में है "g" और "E" भी लगेगा तो वह Particle का acc" "g" से change होकर "2g" हो जाएगा।

eg.)



Determine max height reached by "q"

In general we learn in 1D that! max. height reached by particle $= \frac{u^2}{2g}$

यहाँ "g" accn है downwards

Sol^n

$F_{downward} = mg + qE$

so $a = g + \frac{qE}{m}$

$$\boxed{h_{max} = \frac{u^2}{2\left[g + \frac{qE}{m}\right]}}$$

इसी को रटना नहीं है बल्कि logically समझ कर याद रखना है

• If "E" is in upward direction

$$\boxed{h_{max} = \frac{u^2}{2\left[g - \frac{qE}{m}\right]}}$$

इसी को आप अच्छे logic से याद रख लें।

नोट: -ve charge का force E के opp

1st Choice

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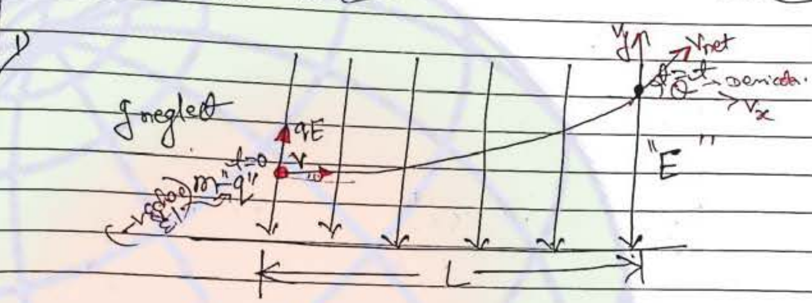
Projectile motion →

दोनों में common time (t) है

eg. 1)



After How much time charge Particle is able to exit the electric field

Sol/ⁿ

$S_{horizontal} = L$ (distance)

$V_{initial} = V$

$a_{horizontal} = 0$ { चूँकि horizontal direction में कोई भी force नहीं लग रहा है। F=0 होने के लिए (F=ma) का "a" को zero होना होगा।

$S = ut + \frac{1}{2}at^2$

$L = Vt$

$$\boxed{t = \frac{L}{V}}$$

ii) Determine the deviation of charge Particle from it's Initial direction of motion when it exit the electric field.

Sol^n $\tan\theta = \frac{v_y}{v_x}$

$v_x = v$

$a_{vertical} = \frac{qE}{m}$

$v = u + at$

$v_y = 0 + \frac{qE}{m} \times \frac{L}{v}$

$v_y = \frac{qEL}{mv}$

$\tan\theta = \frac{qEL}{mv^2}$

(iii) Determine % change in kinetic energy if angle of deviation ($\theta = 60°$)

Sol^n

$$\% \text{ change in K.E} = \frac{\frac{1}{2}mv_{net}^2 - \frac{1}{2}mv^2}{\frac{1}{2}mv^2} \times 100$$

$$\% \text{ change in K.E} = \frac{\text{final} - \text{Initial}}{\text{Initial}} \times 100$$

V_{net} =

$\theta = 60^\circ$

$\tan 60 = \frac{V_y}{V_x}$ $\quad \because \tan 60 = \sqrt{3}$

$V_y = \sqrt{3}\, V_x$

$V_{net} = \sqrt{V_x^2 + V_y^2}$

$= \sqrt{V^2 + 3V^2}$

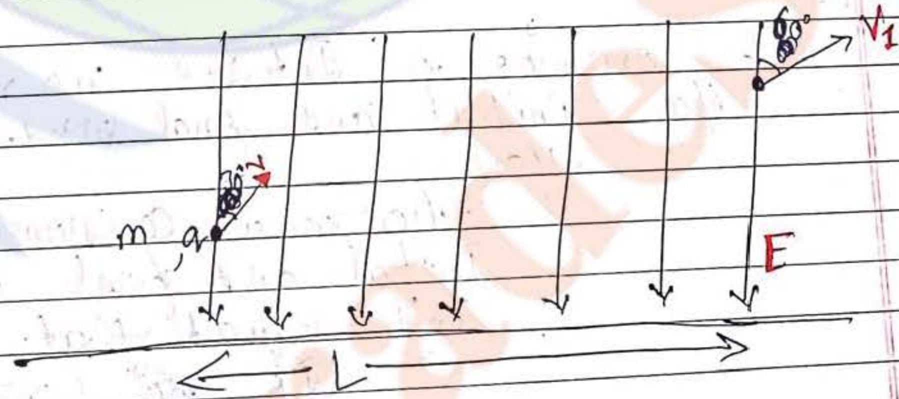
$= 2V$

Shortcut:
horizontal component are equal
$V_{net} \cos\theta = V$
$V_{net} \cos 60^\circ = V$
$V_{net} = 2V$

So,

$\% \text{ chang in } K.E = \left(\left(\frac{V_{net}}{V}\right)^2 - 1\right) \times 100$

Q2



Determine % chang in K.E. when it exit the electric field.

1st Choice

Note

Soln

$\tan 30^\circ = \frac{V_y}{V_x}$ $\quad V\sin 30 = V_1 \sin 60$

$V = \sqrt{3}\, V_1$

$\frac{1}{\sqrt{3}} = \frac{V_y}{V_x}$

$V_x = \sqrt{3}\, V_y$

$\%$ chang in K.E $= \left[\left(\frac{V_1}{V}\right)^2 - 1\right] \times 100$

$= \left(\frac{1}{3} - 1\right) \times 100$

$= -\frac{2}{3} \times 100$

$= -\frac{200}{3}\,\%$

$= -66.7\%$

Suggestion

If cnamene is Intersed in a relationship b/co Initial and final speed.

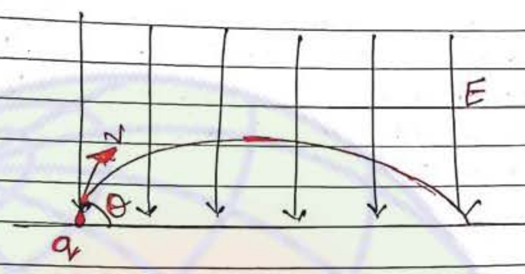
then

we take horizonal component of Initial and final velocity and equate that.

(If horizonal acc^n is Zero.)

End

Note

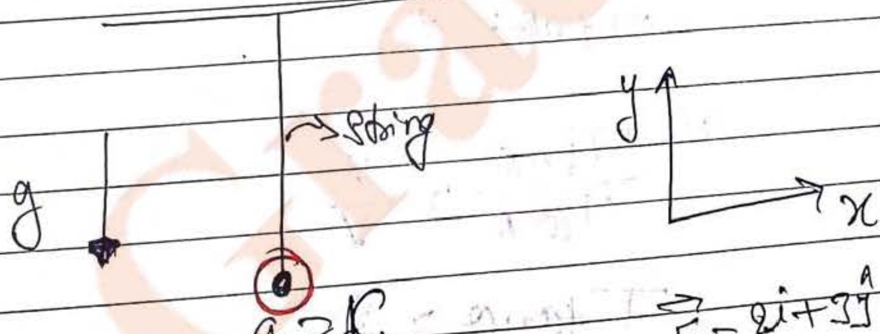


Replace "g" by $\frac{qE}{m}$ or "a" downward

In projectile motion formula Replace "g" by $\frac{qE}{m}$ or downward acceleration.

$$\text{Range} = \frac{v^2 \sin 2\theta}{\frac{qE}{m}}$$

Ex.



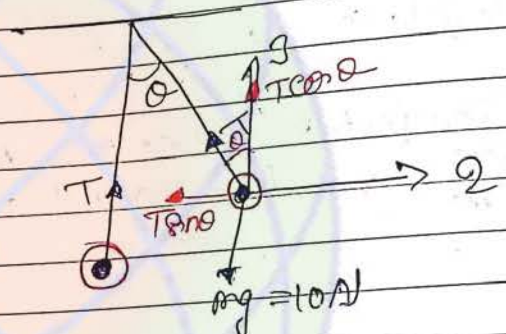
$q = 1C$, $\vec{E} = 2\hat{i} + 3\hat{j}$

$m = 1\,kg$

1st Choice

If an electric field $\vec{E} = 2\hat{i} + 3\hat{j}$ is switched on in this Region. Determine the angle that string made with vertical in new equilibrium position.

Sol^n



$F = qE$

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

$= 1(2\hat{i} + 3\hat{j})$

$\vec{F} = 2\hat{i} + 3\hat{j}$

$T\cos\theta + 3 = 10$

$T\cos\theta = 7$

$T\sin\theta = 2$

So $\frac{T\sin\theta}{T\cos\theta} = \frac{2}{7}$

$T\tan\theta = \frac{2}{7}$

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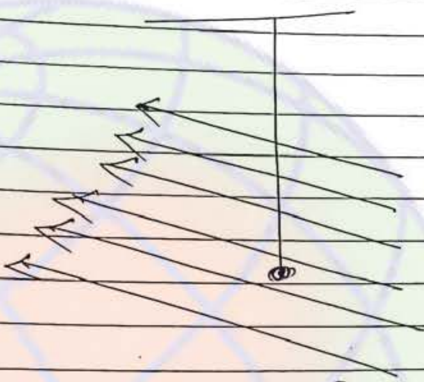
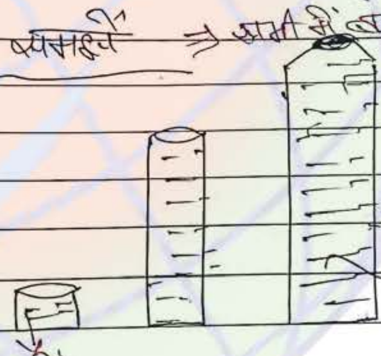
Date / /

(सलोह)



($\vec{E}$) Intensity समझिए ⇒ सामने से बराबर रेखा का रखा गया



⇒ इसमें $\vec{E}$ कम होगा चूंकि रेखाओं का density लगेगा।

इसमें $\vec{E}$ अधिक होगा क्योंकि अधिक रेखा density होगा।

"E" due to Point charge (sulton) Point charge

$$F = \frac{KQ \times q_0}{r^2}$$

$$\boxed{E = \frac{F}{q_0} = \frac{KQ}{r^2}}$$

$$\vec{F} = \frac{KQ\, q_0\, \vec{r}}{r^3}$$

So,

$$\boxed{\vec{E} = \frac{KQ}{r^3}\vec{r}}$$

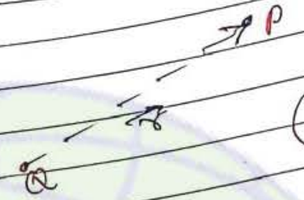
(Q sign के साथ)

→ यह formula 3-D का आधार है।

→ This formula help in 3-D quanta

1st Choice

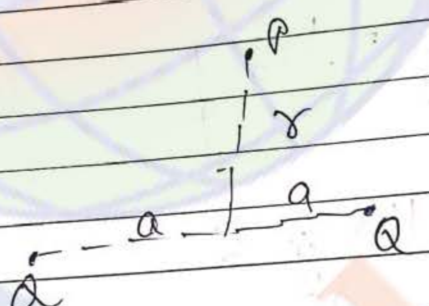
Note:->



$\vec{r} =$

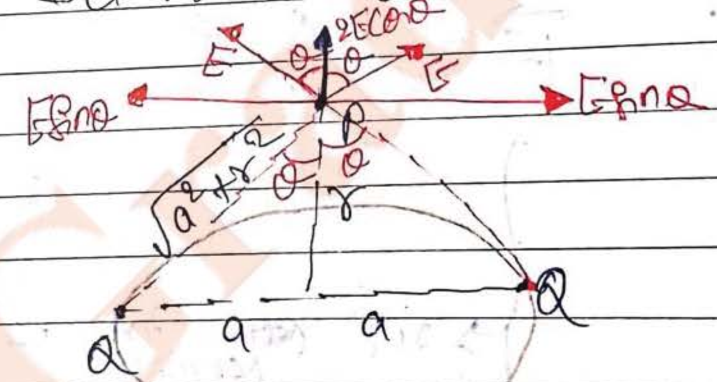
An "$\vec{E}$" is nothing but electric field (electric field intensity). Therefore it also follows "Superposition Principal."

Ex.1



Determine "E" at "P".

Sol/n



1st Choice

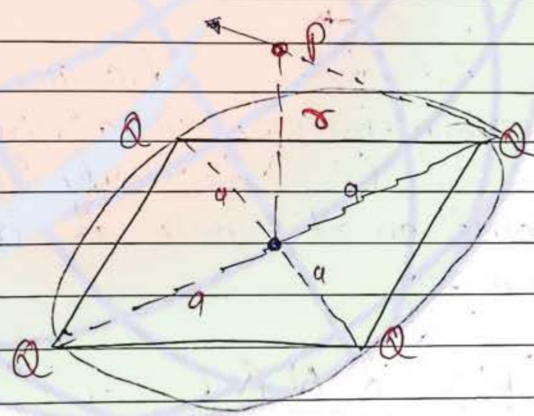
$\because$ $E = \dfrac{KQ}{a^2+a^2}$

$\cos\theta = \dfrac{r}{\sqrt{a^2+r^2}}$

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

$= \dfrac{2KQr}{(r^2+a^2)^{3/2}}$

Exp.



① Determine "E" at Point "P".

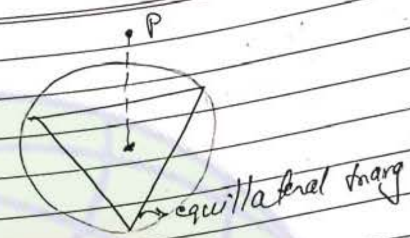
Sol

नोट :→ cos "4" का concept use हो रहा है।

$E_{net} = 4E\cos\theta$

$= \dfrac{4KQr}{(a^2+r^2)^{3/2}}$

Q.



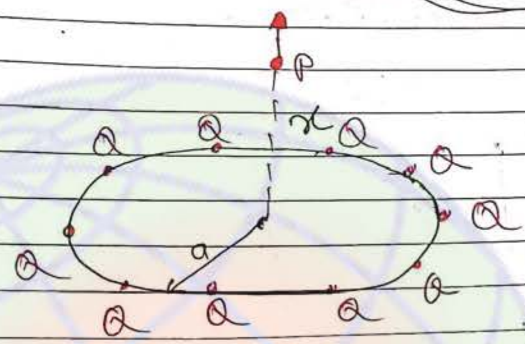
$$F_{net} = \frac{3KQr}{\cdot}$$

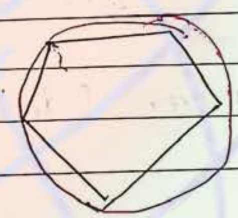
Notes—
Trick by G.B. Sir →
I) If "N" Identical charges are placed symmetrically on a circle, then Electric field Intensity ($\vec{E}$) at any point on the axis of circle is given by

$$\boxed{E = \frac{KNQr}{(r^2+a^2)^{3/2}} = \frac{NKQr}{(r^2+a^2)^{3/2}}}$$

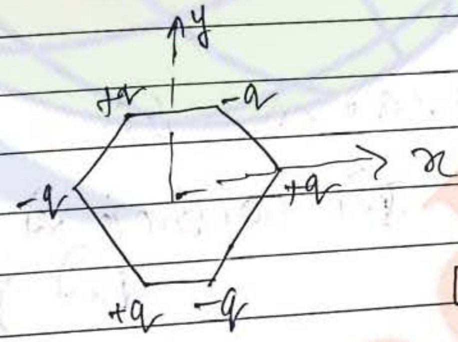
II) If charges are not Identical or not placed symmetrically then at any point on the axis we can say that component of electric field (E) along the axis of circle is given by :—

$$\boxed{\text{Component of "E" along axis} = \frac{k \sum \text{of all charge} \, r}{(r^2+a^2)^{3/2}}}$$





IIT 2008



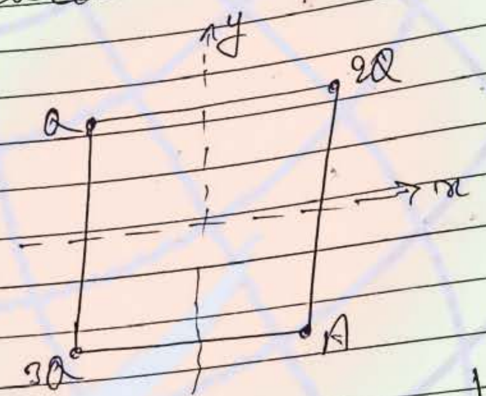
"z" axis का co-ordinate

E at (0, 0, 2) = ?

Ans ⇒ E is Zero

Sheet:→ Ex1 → 8, 9, 10 68
Ex2 → 14, 10, 11, 6,
Q. PPE No2 → 9, 10, 11, 8, 7

Ex9.) what charge should be placed at point "A" so that component of "E" along "Z" axis at (0,0,a) becomes zero.



at (0,0,a)

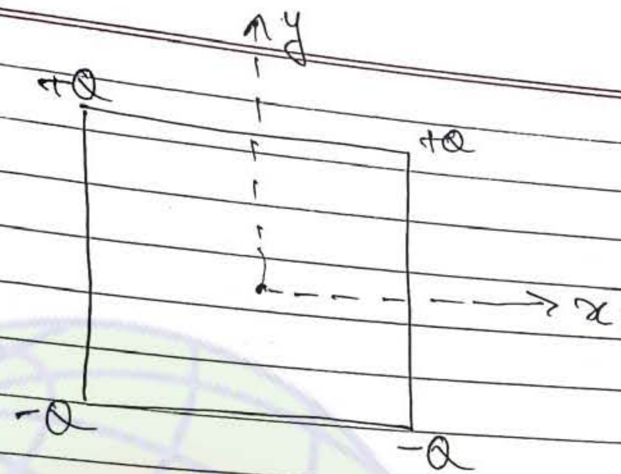
Square of side "a".

Sol: At "a" we put charge of $-6Q$

$\because$ $Q + 3Q + 2Q = 6Q$

इसे charge से cancel करने के लिए $-6Q$ चाहिए

Q.)

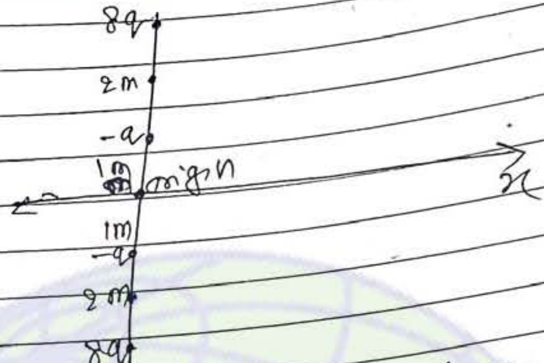


Direction of E at $(0, 0, a)$ = ?

Ans → -ve y-axis.

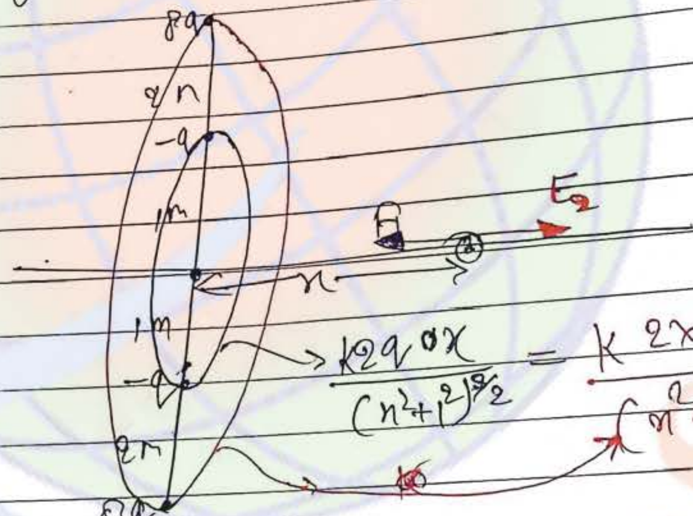
Date / /

Ex



At what point on the x-axis 2μC charge should be placed so that net force on 2μC is zero.

Sol^n



$$\frac{k\,2q\,x}{(x^2+1^2)^{3/2}} = \frac{k\,2\times 8q\,x}{(x^2+2^2)^{3/2}}$$

$F = q\,E_{net}$

$\because F = 0$

$\therefore E_{net} = 0$

Time बर्बाद नहीं करना है circle वाले trick को use करना है

Electric Dipole →

i) Electric dipole is a arrangement in which two equal and opposite charges are placed at certain separation.

$+q$ •- - - - l - - - -• $-q$

ii) Real life example of dipole →

H_2O, HF, NH_3

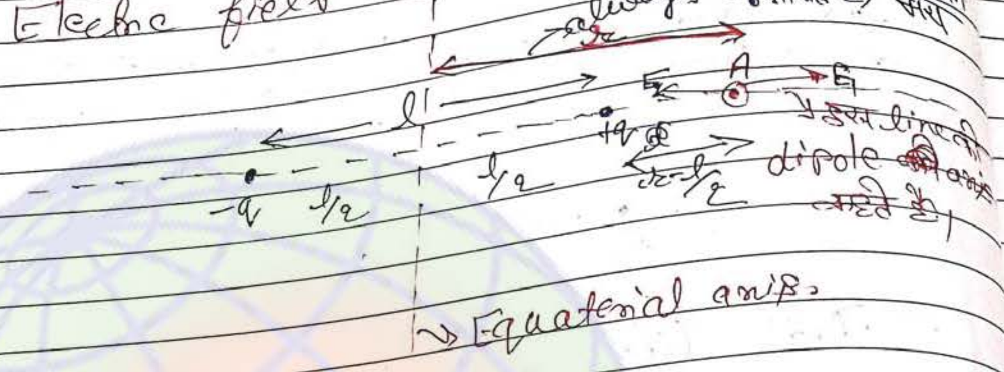
$\overset{\delta+}{H} \longleftarrow \overset{\delta-}{F}$

iii) To define any dipole, dipole moment is required

$+q$ • $\longleftarrow 2l \longrightarrow$ • $-q$

$2q$ • $\longleftarrow l \longrightarrow$ • $-2q$

☆ Electric field Intensity due to a dipole



E at any point on dipole axis ⇒

$\vec{E_A}$ ⇒ vector sum of E of charge "+q" and "-q".

$$= E_1 - E_2$$

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

{ If $r >>>>>>>> l$
then dipole is short dipole }

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

1st Choice

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Note: - In chemistry $H^{\delta+} \text{---} Cl^{\delta-}$, $+ \rightarrow$ | In physics इसका उल्टा है

(Chemists original concept मानते है)

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

$$\boxed{E_A = \frac{2kql}{r^3}}$$

$\because P = ql$

$\because E \propto q \times l$

or $\boxed{E_A = \frac{2kP}{r^3}}$

(P) Dipole moment:-

Dipole moment (P) = either charge × seperation b/w charge

$P = ql$

▷ Dipole moment is a vector quantity it's direction is from "-ve" charge to "+ve" charge

$P = ql$

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

Notes

$\vec{p} = q\left(x_2 - x_1\right)\hat{i} + \left(y_2 - y_1\right)\hat{j} + \left(z_2 - z_1\right)\hat{k}$

P → dipole

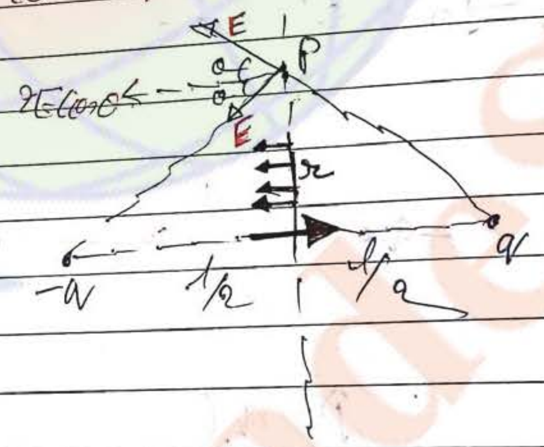
2) unit of dipole is coulomb-meter.

3) At the axis of dipole

$$\boxed{E_{axis} = \frac{2kP}{r^3}}$$ → याद रखें।

4) Imp. बात :- At the axis of dipole direction "E" is in the direction of P(dipole) except at those point which lies b/w "-q" and "+q"

5.) E at equitorial axis →



E at equitorial axis :-

$$E = \frac{kq}{r^2 + \frac{l^2}{4}}$$

1st Choice

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$$\cos\theta = \frac{l}{2\left(r^2 + \frac{l^2}{4}\right)^{1/2}}$$

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

$$= \frac{kql}{\left(r^2 + \frac{l^2}{4}\right)^{3/2}}$$

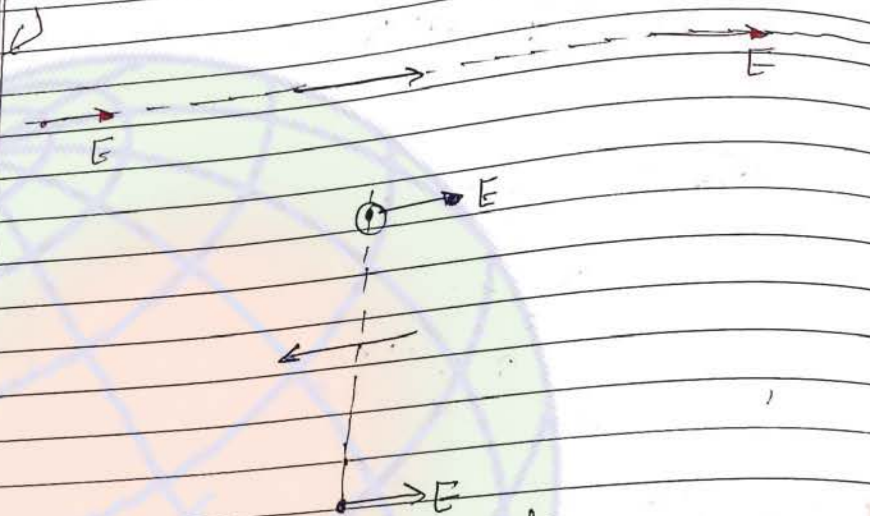
If $r >>>>>>>>> l$

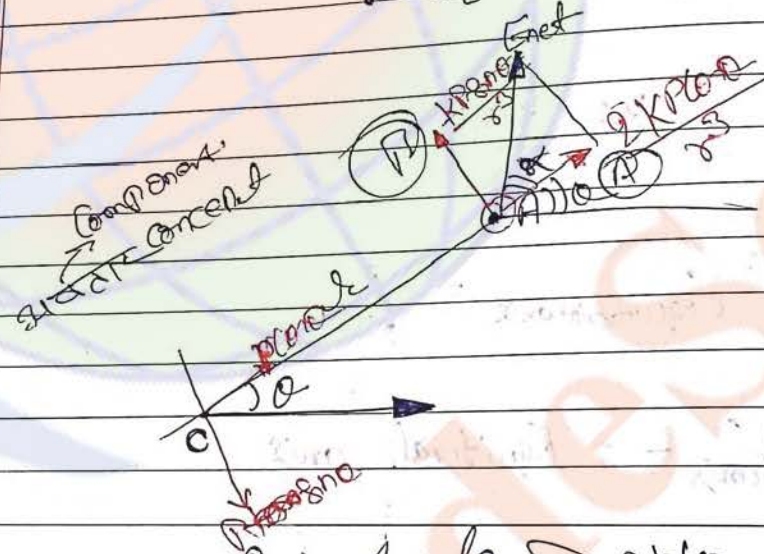
$$E = \frac{kql}{r^3}$$

$$\boxed{E_{\text{Equitorial axis}} = \frac{KP}{r^3}}$$

$$\boxed{E_{\text{axis}} = 2\, E_{\text{Equitorial axis}}}$$

Direction of "Equitorial axis" is Anti-parallel to "P".





(Q1.)

θ ⇒ Angular Position of Point "A"

Determine E at Point "A". and the the angle made by electric field intensity with P.

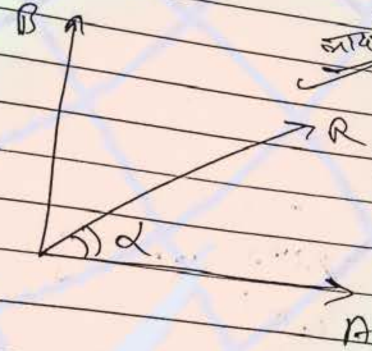
Sol^n.

$$E_{net} = \sqrt{\frac{k^2p^2}{(r^3)^2}\left[\sin^2\theta + 4\cos^2\theta\right]}$$

$$\boxed{E_{net} = \frac{kP}{r^3}\sqrt{1+3\cos^2\theta}}$$

आवश्यक or

$$\boxed{E_{net} = \frac{kP\sqrt{3\cos^2\theta+1}}{r^3}}$$



$$\tan\alpha = \frac{B}{A} = \frac{1}{2}\tan\theta$$

$$\tan\alpha = \frac{1}{2}\tan\theta$$

$$\boxed{\tan\alpha = \frac{1}{2}\tan\theta}$$

Angle of Enet with "P" = $\theta+\alpha$

Examiner can given Angle of ~~Enet~~ Enet with "P" and can ask angular position

1st Choice

of Point "A" (θ)

Then two equation is used.

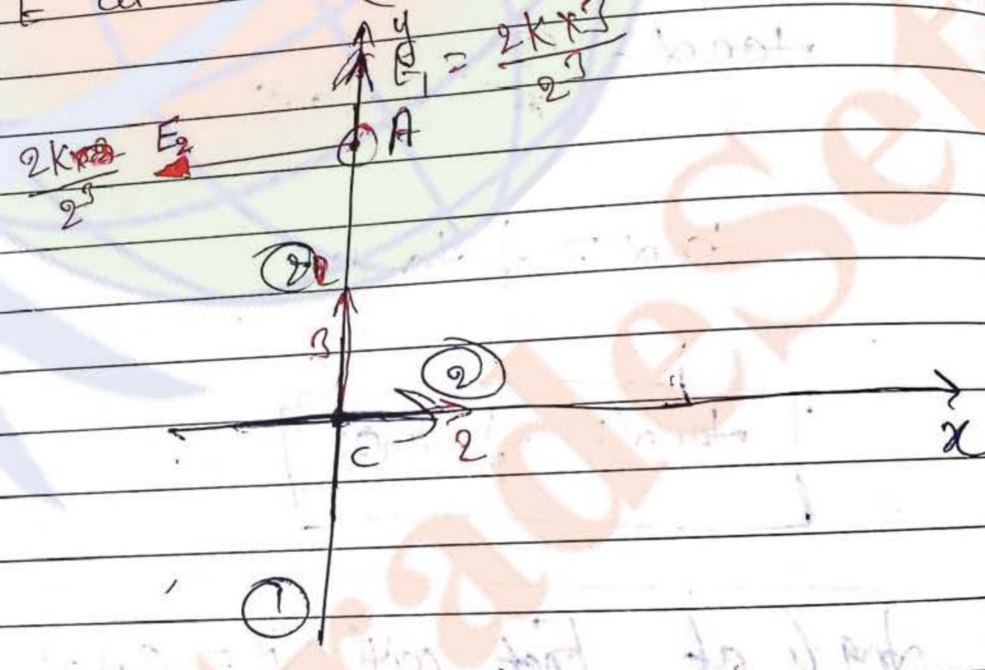
i) $\boxed{\tan\alpha = \frac{1}{2}\tan\theta}$

ii) Angle of Enet with "P" = $\theta + \alpha$

Examiner की गलती

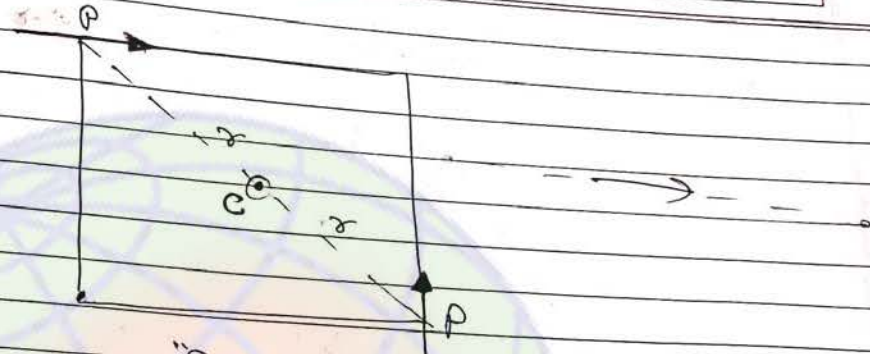
$\vec{P} = 2\hat{i} + 3\hat{j}$ is situated at origin determine E at (0, 2, 0)

Sol



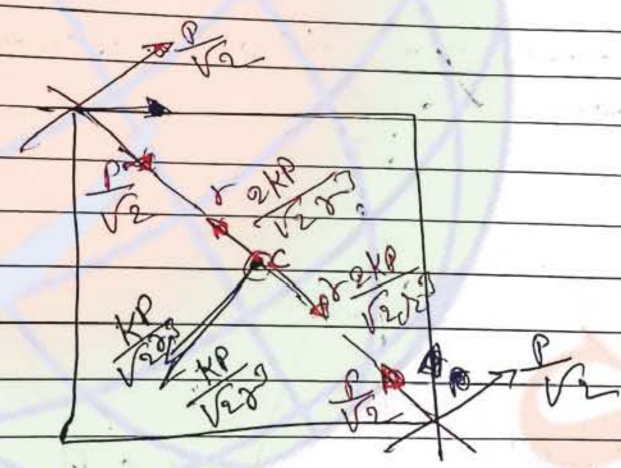
$$E_{net} = \frac{2k\times3}{r^3}\hat{i} - \frac{2k\times2}{r^3}\hat{j}$$

Ex.



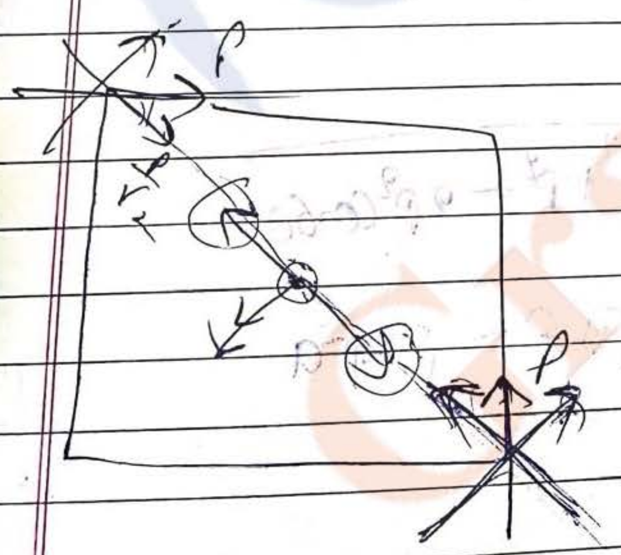
"Square"

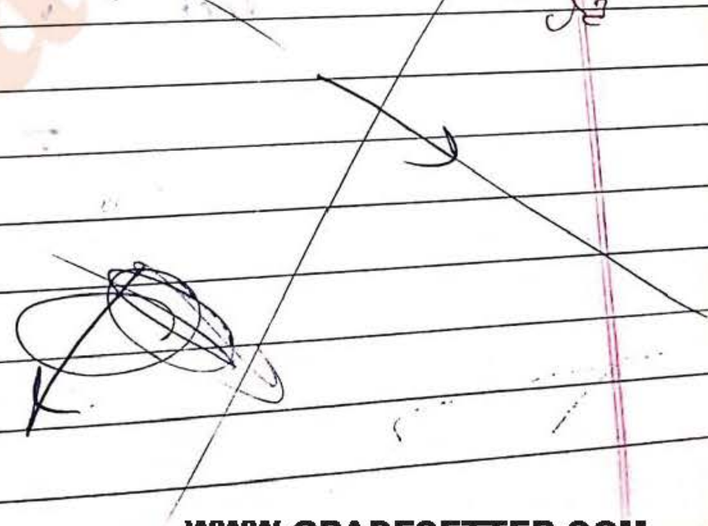
80



Ans :→ $\frac{KP}{\sqrt{2}r^3} + \frac{KP}{\sqrt{2}r^3} \rightarrow \frac{2KP}{\sqrt{2}r^3}$

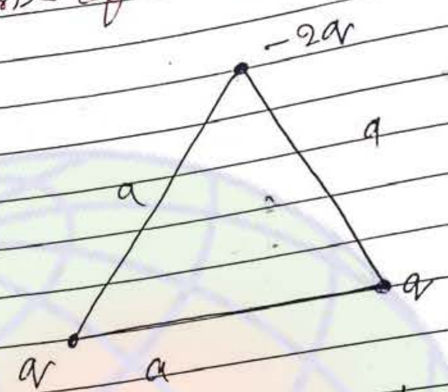
$\frac{\sqrt{2}KP}{r^3}$



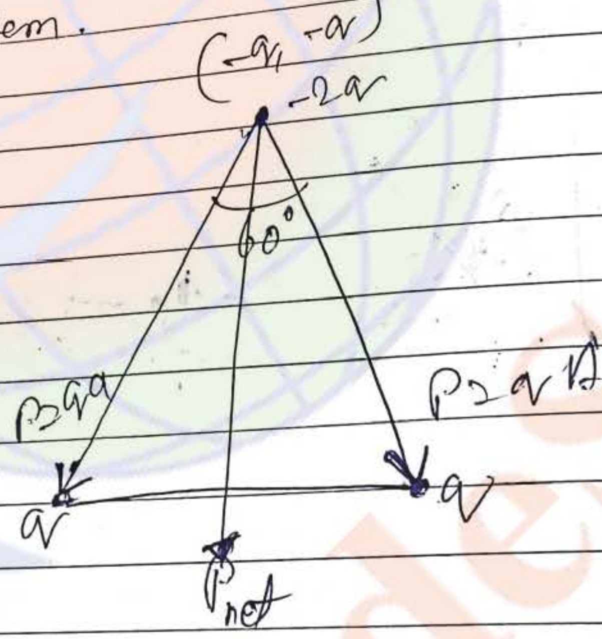


1st Choice

Question's of dipole moment :→

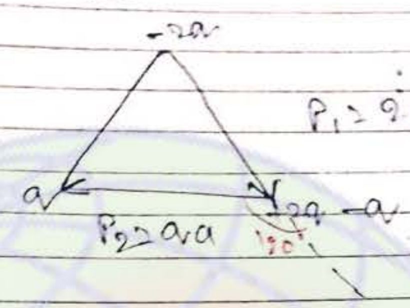


Determine dipole moment of the system.



$$P_{net} = \sqrt{p^2 + p^2 + 2p^2\cos 60^\circ}$$

$$= \sqrt{3}p = \sqrt{3}qa$$

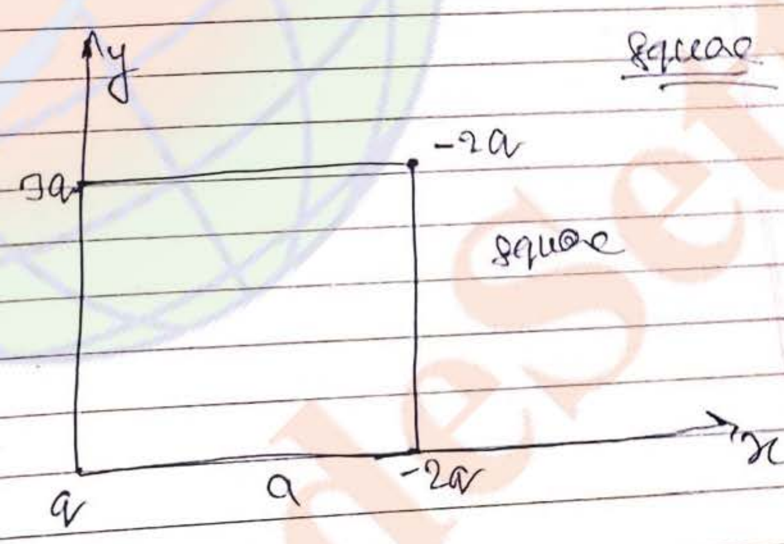


$P_{net} = \sqrt{3}\, qa$

$$P_{net} = \sqrt{(qa)^2 + 4(qa)^2 + 2 \times 2qa \times qa \times \left(\frac{-1}{2}\right)}$$

$$= \sqrt{3}\, qa$$

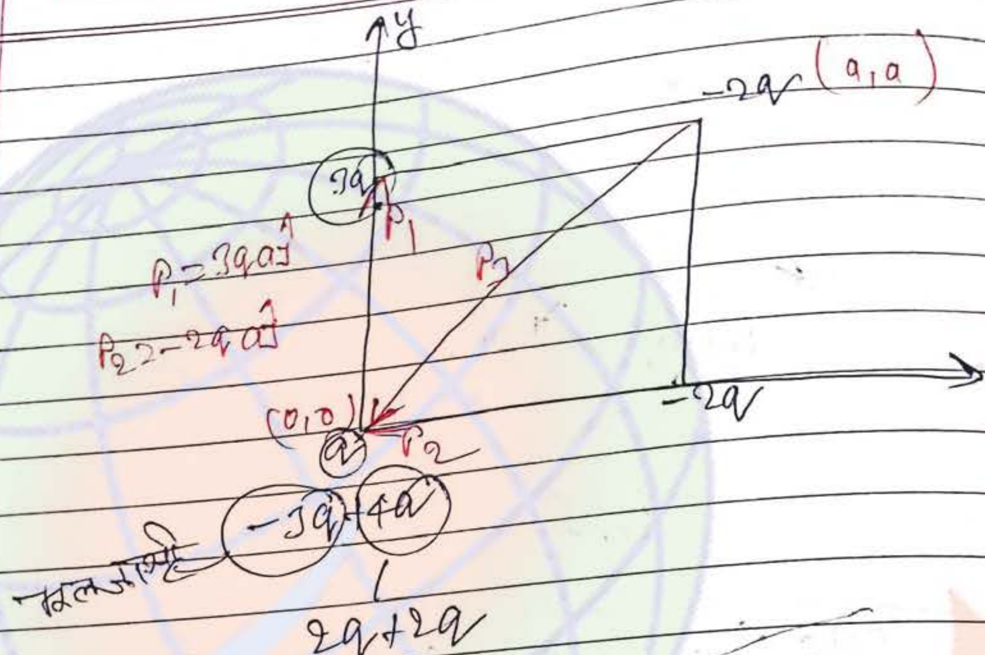
Square



Determine dipole moment vector

80/4

H.W Ex 1 ⇒ 18, 4 9,
Ex 2 ⇒ 26, 28, 29, 31, 34
D.P.P. SA Q. 1



$\vec{P_3} = 2q[-a\hat{i} - a\hat{j}]$

$\vec{P_3} = -2qa\hat{i} - 2qa\hat{j}$

Electric Potential energy and electric Potential

i) Electric force is a conservative force and workdone by this force does not depend on the path followed by the particle or body. workdone by the electric force depend on Initial and final Position.

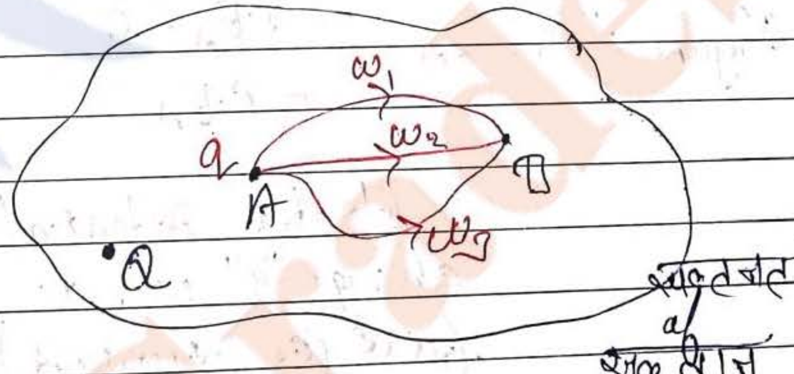
ii) workdone by electric force = − Workdone against E.F

iii) workdone against electric force is equal to

workdone against $E.F = (P.E_f - P.E_i)$

(electric Potential energy change.)

iv) workdone by $E.F = -(P.E_f - P.E_i) = P.E_i - P.E_f$



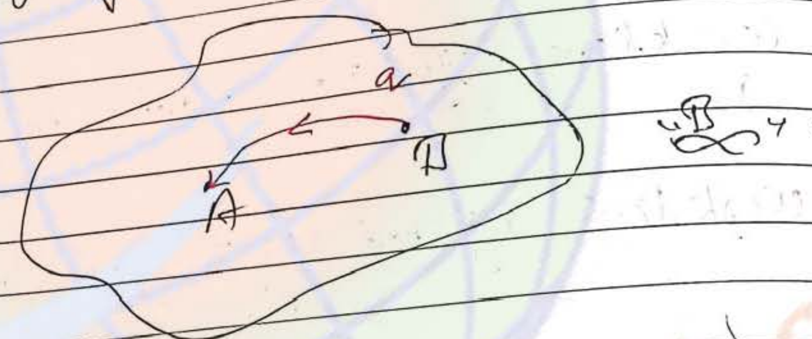
$$\boxed{W_1 = W_2 = W_3}$$

workdone by electric force or electric field of those स्रोत आवेश who are not moving but fixed at their position.

v) Potential energy is a relative term and it need refrence to define potential energy at any point.

Refrence of P.E is taken at Infinity

VI)



$$W_{against\ E.F\ B \to A} = P.E_A - P.E_B$$

$$W_{against\ E.F\ \infty \to A} = P.E_A - 0$$

$$= P.E_A$$

Electric potential energy of charge "q" w.r.t. electric field (or स्रोत आवेश) at Point

VII) E. Potent...

electric ... is define...

force (Refr...

VIII) Elect... or ...

IX) electric... and ...

X) W...

XI) Ele...

vii) E Potential energy of charge "q" w.r.t. E =

electric poten energy of charge "q" w.r.t. E is defined as:-
workdone against electric field or electric force in bringing ~~charge~~ charge "q" from Infinity (Refrence point) to the given point

viii) Elect potential energy can be +ve, -ve or Zero.

ix) electric potential energy is a scaler quantity and it's unit is Joule.

x) $$W_{by\,E.F\,A\to B} = -W_{by\,E.F\,B\to A}$$

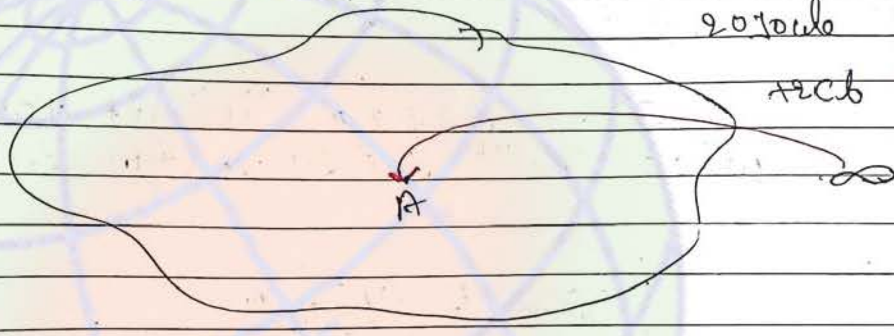
$$W_{against\,E.F\,A\to B} = -W_{against\,E.F\,B\to A}$$

xi) Electric Potential

Electric Potential →

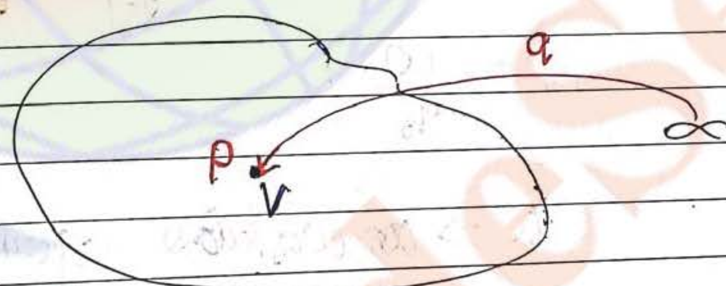
i) Electric potential at any given point is defined as :-

The workdone against E.F in bringing unit the charge from "∞" to that given point.



$W \propto q$

ii) Electric potential is just like भाग of workdone

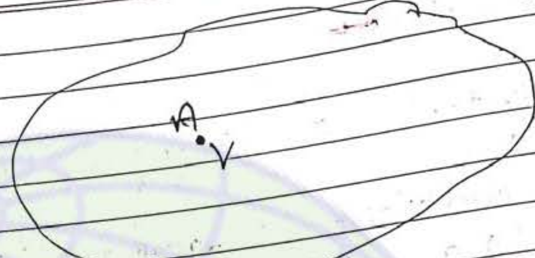


Q.IMP

$$\boxed{W_{\text{against E.F } \infty \to P} = qV}$$

$V \Rightarrow$ Potential at "P" due to sultanat of Sultan.

$q \Rightarrow$ entering in sultanat of sultan from "∞".



Imp $\boxed{E.P.E = qV}$

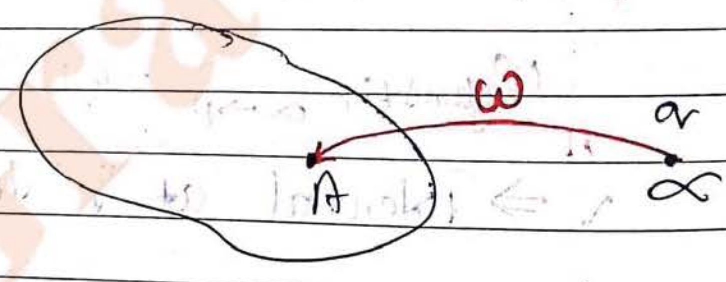
E.P.E of charge "q" at Point "A" where "V" due to sultan is known,

$\boxed{V = \frac{E.P.E}{q}}$ of q

iii) electric potential is also defined as potential energy per unit charge.

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

$W \Rightarrow$ workdone against E.F $_{\infty \to A}$

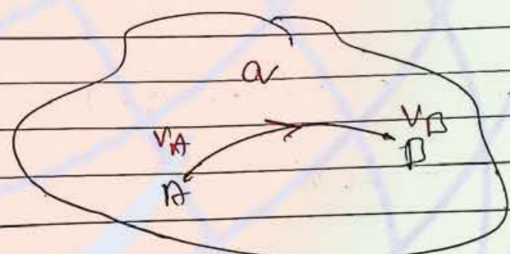


v) Potential is also a related term and it refrence is taken at "∞".

vi) Unit of Potential is volt.

vii) Potential can be +ve, -ve or Zero.

viii) In ~~...~~ all formulas of EPE and workdone Put q, V, W and EPE with sign in their sign are known to us.



$$W_{by\ E.F} = -(qV_B - qV_A)$$

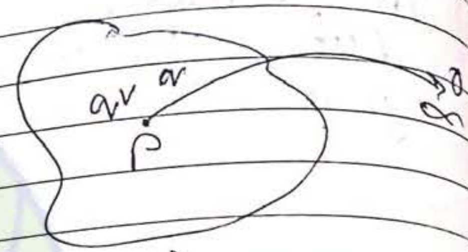
$$= -q(V_B - V_A)$$

1st Choice

Ex.) workdone by electric force in bringing $-2\mu C$ charge ~~from~~ a given point to "∞" is $-20 \mu J$. Determine potential at given point.

Sol/n $q = -2\mu C$

$\cancel{V = -20\mu C}$



$\cancel{P.E/x}$

$$W_{by\ E.F_{P \to \infty}} = -(0 - qV)$$

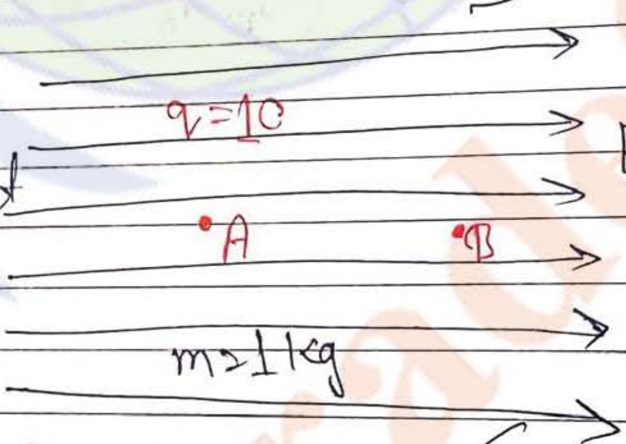
$$-20 = qV$$

$$-20 = -2 \times V$$

$$V = 10 \text{ volt}$$

Ex.)

neglect



$E \Rightarrow 10 N/C$

$q = 1C$

$m = 1kg$

charge "q" is released from rest at point "A". At $t = 4$ sec. it reach at point "B"
Determine $V_B - V_A$

So) 4

$$W_{by\,E.F\,A\to B} = -q\left[V_B - V_A\right]$$

$$F = qE = 10N$$

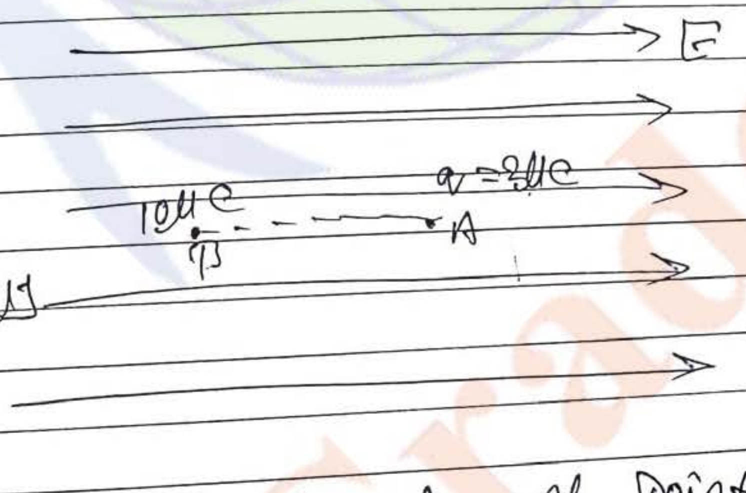
$$S = \frac{1}{2}\times\frac{qE}{m}\times t^2 = \frac{1}{2}\times 10\times 16 = 80$$

$$80 = -1\,(V_B - V_A)$$

$$V_B - V_A = -80\,\text{volt}$$

$$W_{by\,E.F} = F\times S = 80\times 10 = 800 \text{ joule}$$

Q.E.)



q is at rest at point "A" and an external force is applied on charge "q" due to which it reach at point "B" with K.E 10 μJ, external force is work done by this

300 μC . Determine $V_A - V_B$?

Sol^n $W_{by\,agent} + W_{by\,Electric\,fo} = 10$

$$30 - q(V_B - V_A) = 10$$

$$+q(V_B - V_A) = \cancel{+}20$$

$$V_B - V_A = 10$$

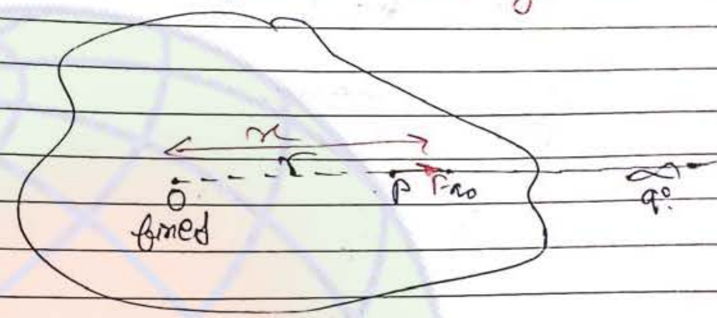
$$V_A - V_B = -10$$

1st Choice

Book

Electric Potential due to Sulton :-

⇒ "V" due to Point charge -



$W_{against}$ E.F. in bringing q_0 $\infty \to P = W$

$$V_P = \frac{W}{q_0}$$

Imp

$$\boxed{W_{by\ E.F.} \text{ in bringing } q_0\ P \to \infty = W}$$

$W_{against}$ E

F is variable

$$F = \frac{KQq_0}{x^2}$$

$$W_{by\ F} = \int_r^\infty F\,dx$$

$$W = KQ \times q_0 \int_r^\infty \frac{1}{x^2}\,dx$$

$$= KQ \times q_0 \left[\frac{-1}{x} \right]_r^{\infty}$$

$$W = \frac{KQq_0}{r}$$

$$W_{agains} = \frac{KQ \times q_0}{r}$$

$$V = \frac{W}{q_0} = \frac{KQ}{r}$$

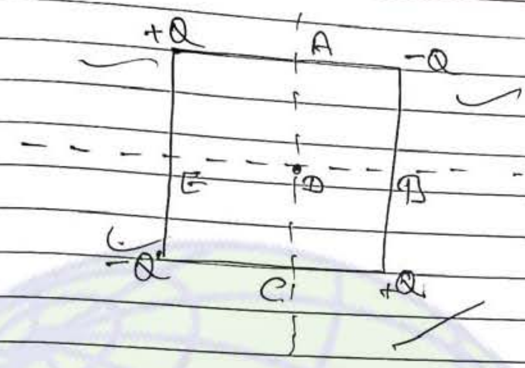
$$\boxed{V = \frac{KQ}{r}}$$

i) K.K. concept — All formula of Potential Put charge with sign

ii) Potential follows superposition theorem

iii) Net potential at any point is the scalar sum of potential's due to individual charge.

[Ex]



Soln

All all the five point's potential is zero

[Ex] Regular polygon of N-side, (N-1) corner पर Q charge है। Determine "V" at centre distance of each corner from centre = r

$$\boxed{V = \frac{(N-1)Q}{r}}$$

Potential निकालना ज्यादा आसान है "E" के मुकाबले because Potential is a scalar quantity.

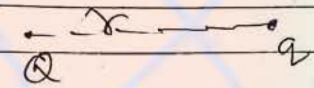
Application of Electric Potential (V) and Electric Potential energy →

Electric Potential energy of system →

method 1st ⇒ Infinity से charge को लाने वाला method

Electric potential energy of system is defined as amount of workdone against electric force in bringing one by one each charge of the system from infinity to respective position of charges in the system.

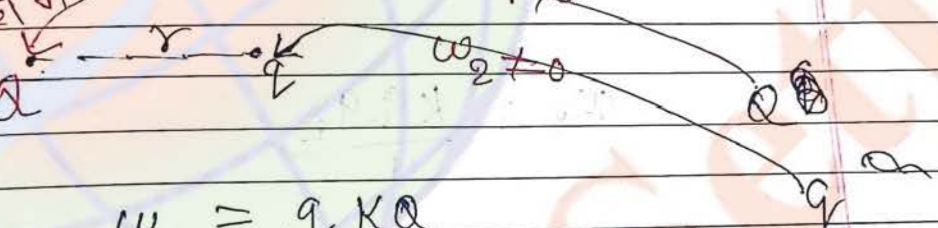
Ex



Determine P.E of system.

Sol/n

~~पहला लाने में पर 80, workdone ⇒ 0~~



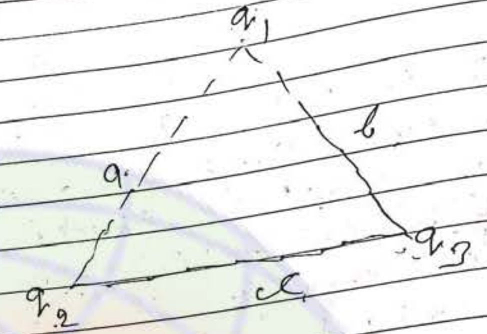
$$W_2 = \frac{q\,KQ}{r}$$

$$P.E = W_1 + W_2$$

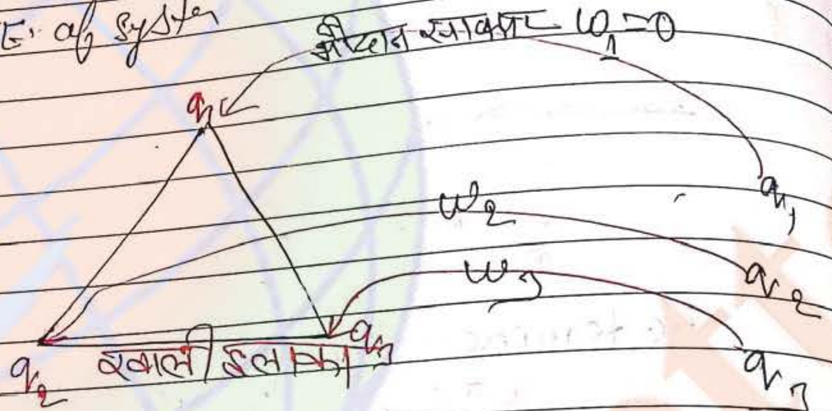
$$= \frac{KQ \times q}{r}$$

1st Choice

Ex



P.E. of system



$$W_2 = \frac{k q_1 q_2}{a}$$

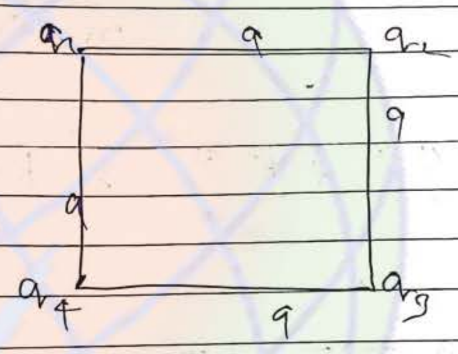
$$W_3 = q_3 \times \left[\frac{k q_1}{c} + \frac{k q_2}{b} \right]$$

$$P.E. = \frac{k q_1 q_2}{a} + \frac{k q_1 q_3}{c} + \frac{k q_2 q_3}{b}$$

2nd method

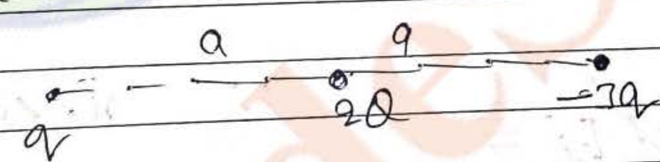
Pair technique or Combination technique →

~~Combine~~ we can determine P.E. of system of charges upto four number of charges by combination technique.
It is basically a जुगाड़ but not a technique.



$$P.E. = \frac{k q_1 q_2}{r}$$

Ex) Deter $\frac{q}{Q}$ if P.E. of system is zero.



Sol

$$P.E. = \frac{K q\, 2Q}{a} + \frac{K q(-3q)}{2a} + \frac{K(2Q)(-3q)}{a} = 0$$

by solving we get. ~~हल करने पर~~

$$\frac{q}{Q} = \frac{2}{3}$$

1st Choice

IIT

fixed Q —— a —— q —— a —— Q fixed

Determine change in P.E. of system if "q" is slightly displaced towards right side by distance "x".

$x <<< a$

Sol^n

$$P.E._i = \frac{KQq}{a} + \frac{KQ^2}{2a} + \frac{KqQ}{a}$$

Now

$$P.E._f = \frac{KQq}{(a+x)} + \frac{Q^2}{2a} + \frac{KqQ}{(a-x)}$$

Now $\because x <<<< a$

$\cancel{P.E_f - P.E_i =}$

$$P.E_f = \frac{KQ \times q \times 2a}{(a^2-x^2)} + \frac{KQ^2}{2a}$$

$$P.E_f - P.E_i = \frac{KQ \times q \times 2a}{a^2-x^2} - \frac{2kQ \times q}{a}$$

1st Choice

ΔPE

method II

Sol^n

P.E

Potential energy or Interaction energy

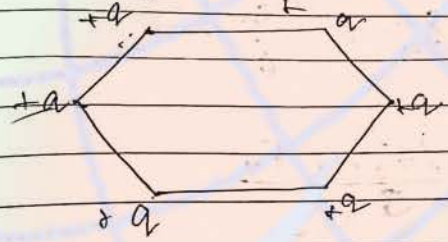
$$= kQ \times a \times 2 \left[\frac{a}{a^2 - x^2} - \frac{1}{a} \right]$$

$$= \frac{kQ \times a \times 2 \times x^2}{a(a^2 - x^2)}$$

$$\Delta PE = \frac{2kQ \times q\, x^2}{a^3}$$

method (II) Potential energy method (by dividing two)

Eg.



Hexagon of side a

Determine P.E. of the system.

Sol^n we solve

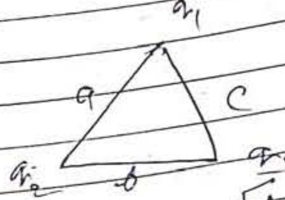
$$\boxed{P.E. \text{ of System} = \frac{P.E_1 + P.E_2 + P.E_3 + \cdots}{2}}$$

$P.E_1 \rightarrow$ charge (q_1) ka P.E with rest of the charge.

$P.E_2 \rightarrow$ P.E of q_2 w.r.t. rest of the charge

1st Choice

ex:⇒



$P.E_1 \Rightarrow q_1 \times \left[\frac{kq_2}{a} + \frac{kq_3}{c}\right]$

$P.E_2 \Rightarrow q_2 \times \left(\frac{kq_1}{a} + \frac{kq_3}{b}\right)$

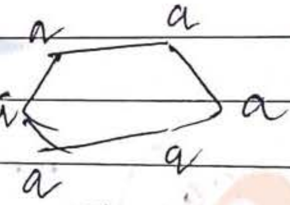
$P.E_3 = q_3 \times V$

$= q_3 \times \left(\frac{kq_1}{c} + \frac{kq_2}{b}\right)$

$$P.E_{Net} = \frac{P.E_1 + P.E_2 + P.E_3}{2}$$

$$= \frac{kq_1 q_2}{a} + \frac{kq_2 q_3}{b} + \frac{kq_1 q_3}{c}$$

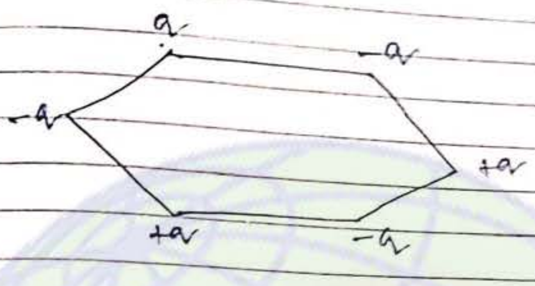
Now
we solve the above given question —



$P.E \text{ of } q = q\left[\frac{ka}{a}\times 2 + \frac{ka\times 2}{r} + \frac{ka}{2a}\right] = 6$

$= \frac{6+6+6 \cdots}{2} = \frac{6 \cdot 6}{2} = 3$[illegible]

Ex.



P.E. of system?

P.E. of system = ?

P.E. of each charge ⇒ C

$$\text{P.E. of system} = \frac{6C}{2}$$

$$= 3C$$

Question's of workdone →

Q.)

Determine workdone by electric force in Increasing the separation b/w charge from r to $2r$.

Sol/n

महिमा उपयोग of P.E. concept →

In variable forces (conservative force) workdone calculate does not Involve Interation so not need pannied.

w. done by EF = $-(P.E_f - P.E_i)$

w. done against E.P ⇒ $(P.E_f - P.E_i)$

(i) w. done by external agent ⇒ $(P.E_f - P.E_i) + (K.E_f - K.E_i)$

or

workdone → Fext
→ Fele

$W_{by\,ext} + W_{by} = \Delta K.E$

$W_{by\,ext} - (P.E_f - P.E_i) = K.E_f - K.E_i$

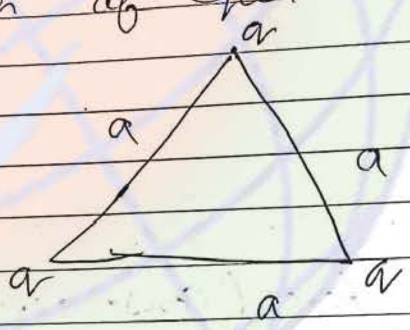
Questo solution
sol,

$$P.E_i = \frac{K(-2Q^2)}{r}$$

$$P.E_f = \frac{K(-2Q^2)}{2r}$$

$$W = -\left[\frac{-2KQ^2}{2r} + \frac{2KQ^2}{r}\right]$$

Determine work done against electric force in shifting charges all at the corner of equilateral Δ of side "a".



(सकल change होते ही mean's energy is changed)

sol $P.E_i = \frac{kq^2 \times 3}{a}$

$$P.E_f = \frac{kq^2 \times 3}{2a}$$

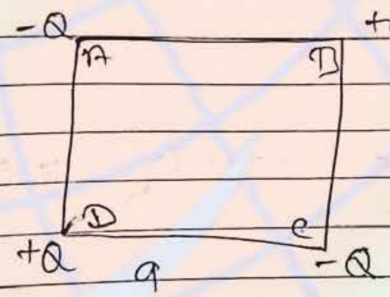
$$W = P.E_f - P.E_i$$

$$= \frac{-3kq^2}{2a}$$

G.P.Sir

जब भी system की शक्ल सूरत दुनिया (configuration) change होगा। Determine P.E of initial and final शक्ल of system and then use the formula's of workdone ~

Q.

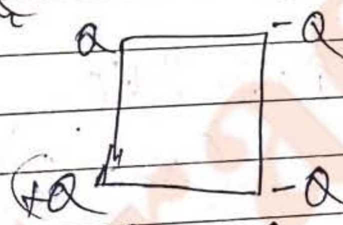


Sq

Determine the workdone in interchanging the charges at "A" and "B".

Sol.

$$P.E_i = \left(\frac{-KQ^2}{a} \times 4 + \frac{KQ^2}{(\sqrt{2}a)} \times 2 + \cancel{\frac{-KQ^2}{a}} \right)$$



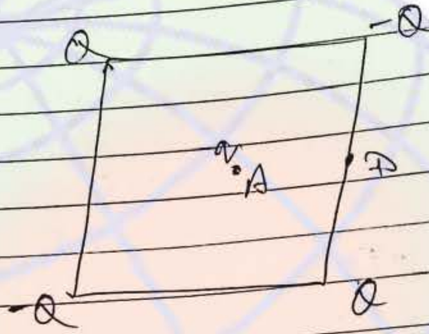
$\cancel{P.E_f}$

$$P.E_f = \left(\frac{-KQ^2}{a} \cancel{\times} - \frac{KQ^2}{\sqrt{2}a} + \frac{KQ^2}{a} \right) 4$$

$$P.E_f = \frac{-KQ^2}{\sqrt{2}a} \times 2$$

$$P.E_f - P.E_i = \frac{-KQ^2}{\sqrt{2}a} \times 2 - \left[\frac{-KQ^2}{a} \times 4 + \frac{KQ^2}{\sqrt{2}a} \right.$$

Imp Q 4.



Square of side a

Determine the work done in shifting "q" from A to D

Sol^n

$$\cancel{P.E_i = -\frac{KQ^2}{a} + \frac{KQ^2}{\sqrt{2}a} - \frac{KQ^2}{a}}$$

$$P.E_i = qV_A$$

$$P.E_f = qV_D$$

$$W = P.E_f - P.E_i$$
$$= q(V_D - V_A)$$
$$= q(0-0)$$
$$= 0$$

Such questions solve shortly

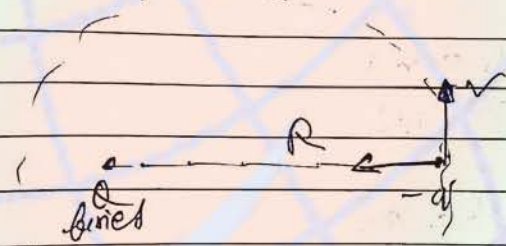
When in a system only one charge change it position then don't write P.E. of the system because it waste our ink as well as time. Therefore in such cases we will write P.E. of that moving charge only w.r.t. rest of the charges.

by the formula $\boxed{P.E = qV}$

Here :>

V > Potential at the position of "q" due to all charges of the system.

Tough question



-q charge is revolving on a circular path under the influence of electric force around Q. Determine the workdone in changing the radius of orbit from "R" to 2R

Sol) q

$$W_{ext} = (P.E_f - P.E_i) + (K.E_f - K.E_i)$$

Here $W_{CF} = 0$ (Note)

Here

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

V → radius

$$\frac{kQ \times q}{r^2} = \frac{mv^2}{r}$$

$$mv^2 = \frac{kQ \times q}{r}$$

$$K.E = \frac{1}{2}mv^2 = \frac{kQ \times q}{2r}$$

$$\cancel{P.E_i = \frac{kQ \times q}{2R}}$$

$$K.E_i = \frac{kQ \times q}{2R}$$

$$K.E_f = \frac{kQ \times q}{4R}$$

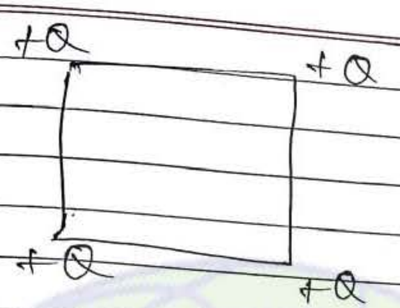
$$P.E_i = \frac{-kQ \times q}{R}$$

$$P.E_f = \frac{-kQ \times q}{2R}$$

Note

$$W = (P.E_f - P.E_i) + (K.E_f - K.E_i)$$

Ref



Input
+Q, +Q
Q+, +Q.

To destroy the system of charge (मिट्टी में मिलाना) workdone is given by minus of P.E. of system.

and this workdone is also known as Binding energy of system

after मिट्टी में मिलाना
(Destroy) ($P.E_f = 0$)

Workdone $= P.E_f - P.E_i$

$B.E = -P.E_i$

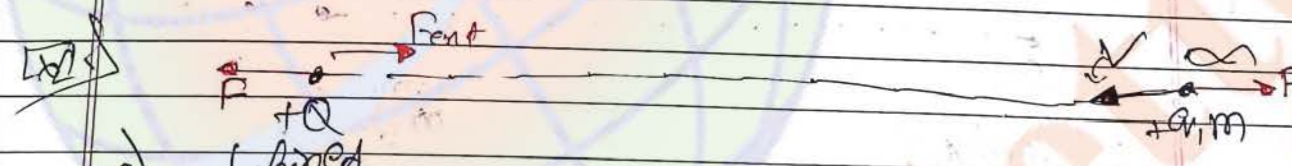
↓

Binding energy

Question of motion and Energy conservation →

प्राविधिक अनुप्रयोग of P.E ⇒

In question of motion if acc^n is variable and examiner is interested in position and velocity not in time then instead of using kinematic with integration we will use energy conservation (condition applied) →



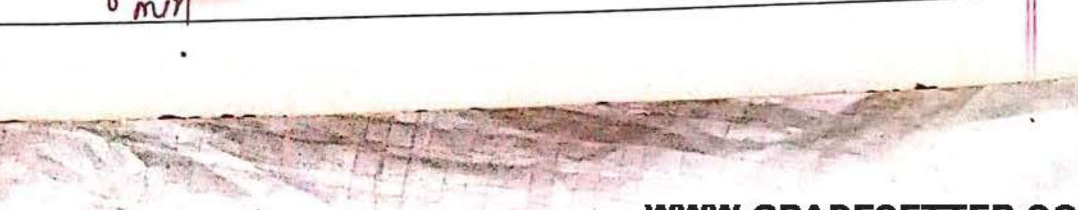
(neglect g)

determine the closest distance of approach of charge q from Q

Here $F_{ext} = 0$, $W_{n.c.f} = 0$

$$\boxed{K.E_i + P.E_i = K.E_f + P.E_f}$$

$$\frac{1}{2}mv^2 + 0 = 0 + \frac{KQq}{r_{min}}$$



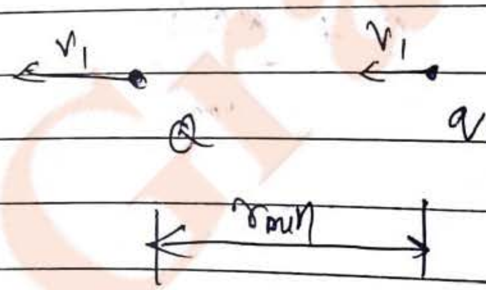
$$\frac{1}{2}mv^2 = \frac{KQq}{r_{min}}$$

$$r_{min} = \frac{2KQq}{mv^2}$$

Determine closest distance of approach.

जब तक दूरी कम होगी तब तक वेग कम होगा।

	100m/s
	60m/s
20m/s	50m/s
दूरी ↓ 10m/s	40m/s
40m/s (when both v is same)	39m/s
दूरी ↑ 41m/s	



$$0 + \frac{1}{2}mv^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_1^2 + \frac{KQ \times q}{r_{min}} \quad \text{--- (1)}$$

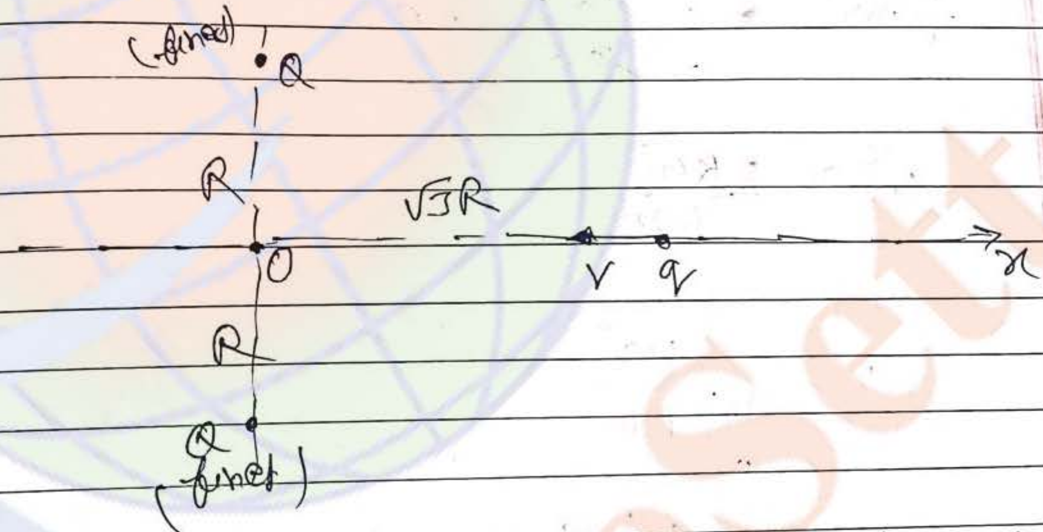
momentum conservation.

$$mv = mv_1 + mv_1 \quad \text{--- (2)}$$

from using eq (1) and (2)

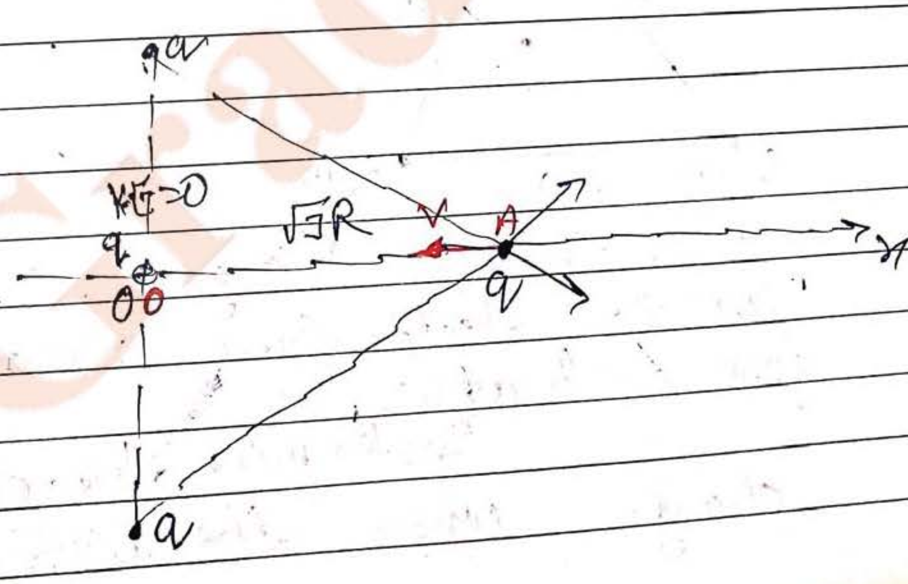
we find $r_{min} = ?$

Ex.



Determine the min^m vel. "v" so that "q" can cross "O".

Sol



1st Choice

Achaarya P.G

$$\frac{1}{2}mv^2 + q \times \left[\frac{kq}{2R} \times 2\right] = 0 + q \times \frac{2kq}{R}$$

$$\frac{1}{2}mv^2 + \frac{2kq^2}{2R} - \frac{2kq^2}{R} = 0$$

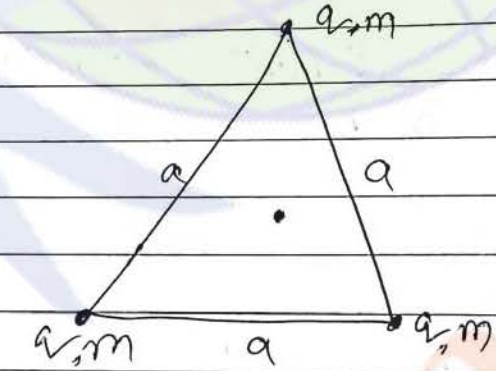
$$\frac{1}{2}mv^2 + \frac{2kq^2 - 4kq^2}{2R} = 0$$

$$\frac{1}{2}mv^2 - \frac{\cancel{2}kq^2}{\cancel{2}R} = 0$$

$$v^2 = \frac{2kq^2}{Rm}$$

$$v = \sqrt{\frac{2kq^2}{Rm}}$$

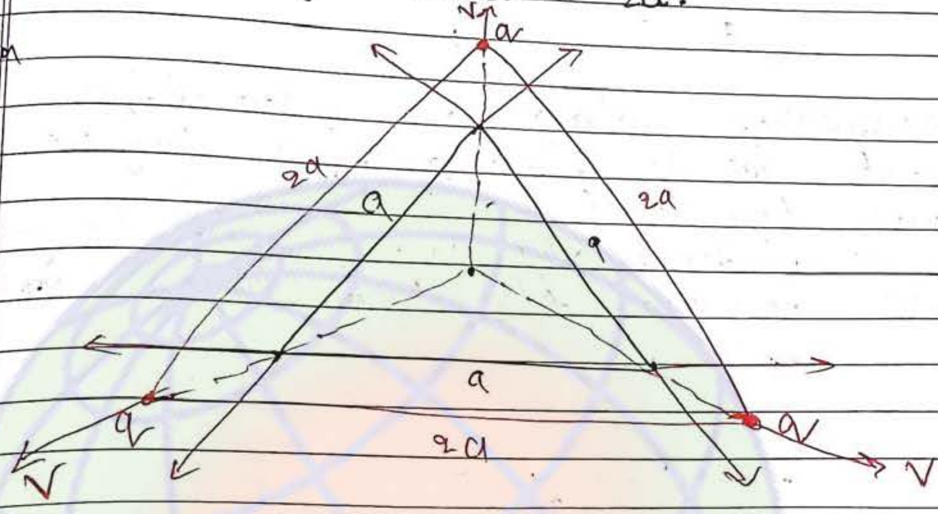
Q.



There three charge are free to move Due to electric force remove apart from each other.
Determine the vel. of each charge when the distance b/w

each charge become "2a".

Sol



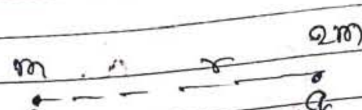
$$0 + \frac{Kq^2}{a} \times 3 = \frac{Kq^2}{2a} \times 3 + \frac{1}{2} m v^2 \times 3$$

$$\frac{3Kq^2}{a} - \frac{3Kq^2}{2a} = \frac{3}{2} m v^2$$

$$\frac{6Kq^2 - 3Kq^2}{2a} = \frac{3}{2} m v^2$$

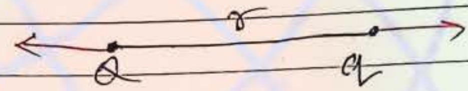
$V =$

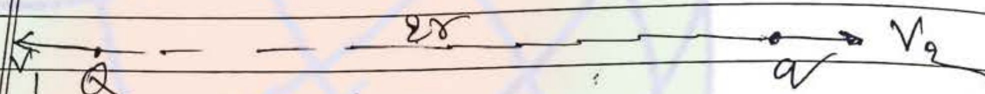
Q5.)



Both charge are released from rest due to electrical force they move away from each other.
Determine the vel. of both charge when separation b/w them becomes 2r.

Solⁿ





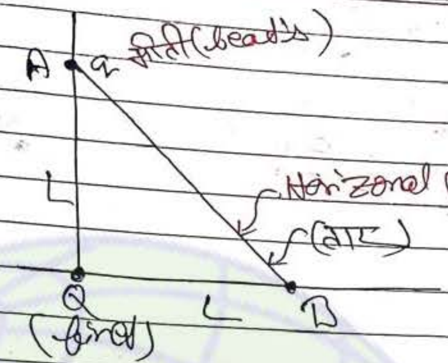
By energy conservation –

$$\frac{KQ\times q}{r} = \frac{1}{2}mv_1^2 + \frac{1}{2}\times 2mv_2^2 + \frac{KQ\times q}{2r} \quad (1)$$

By momentum conservation – ($\because$ external force is zero)

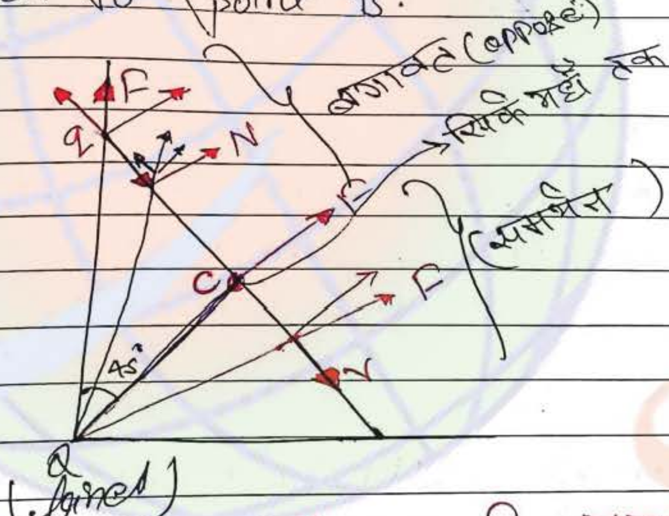
$$0 = mv_1 - 2mv_2 \quad (2)$$

from eq (1) and (2)
we find v_1 and v_2



Determine the min. vel. "v" that should be given to bead's so that it can reach to point "B".

Sol

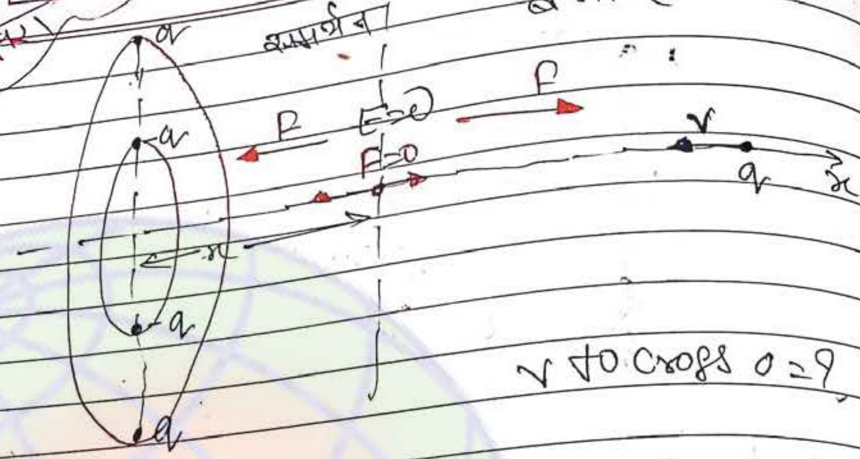


Here
$W_{ext} = 0$
so, we use
energy conservation

Question of चालाकी भरा →

$$\frac{1}{2}mv^2 + \frac{KQq}{L} = 0 + \frac{KQq \times \sqrt{2}}{L}$$

$v =$



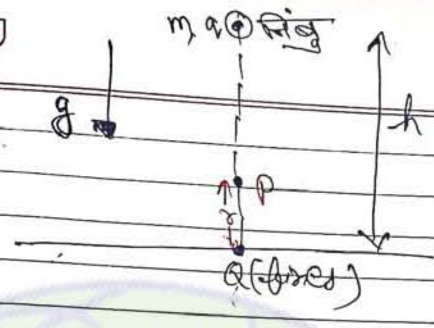
v to cross $O = ?$

$$\frac{K \times 2qx}{(x^2+a^2)^{3/2}} = \frac{K8qx}{(x^2+(2a)^2)^{3/2}}$$

नोट ⇒ यदि "x" का value Imaginary or complex आ जाए it means no point in plane in which $F=0$.

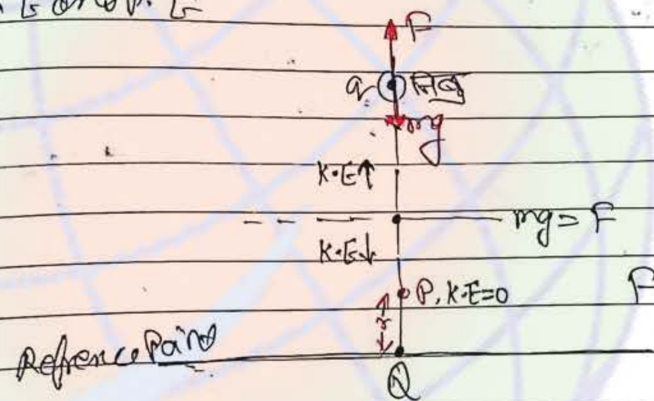
In question of असंतुलित and साम्यावस्था direction of force changes in such questions we will find that point where force is zero or where direction of force is change.

and then apply energy conservation at that point and Initial point.



Determine the height "h" or minimum height "h" from where lemon is released so that it can reach to point "P". Also draw the variation of K.E and P.E

Sol



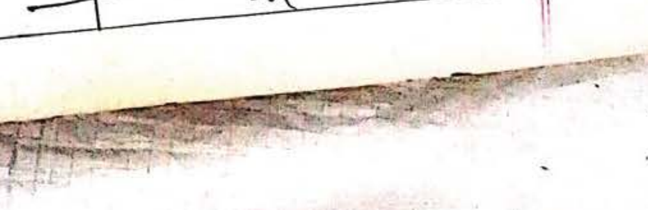
$mg > F$; $F_{net}\downarrow$

$F > mg$; $F_{net}\uparrow$

$$0 + mgh + \frac{KQq}{h} = 0 + \frac{KQq}{r} + mgr$$

$h =$

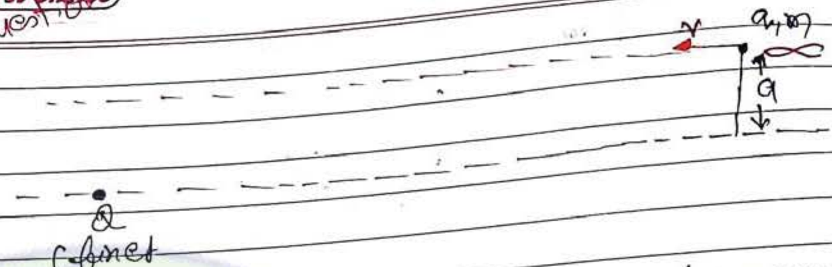
Notes → Here the variation of K.E and P.E



(Concept whole (Δ 4th class) question)

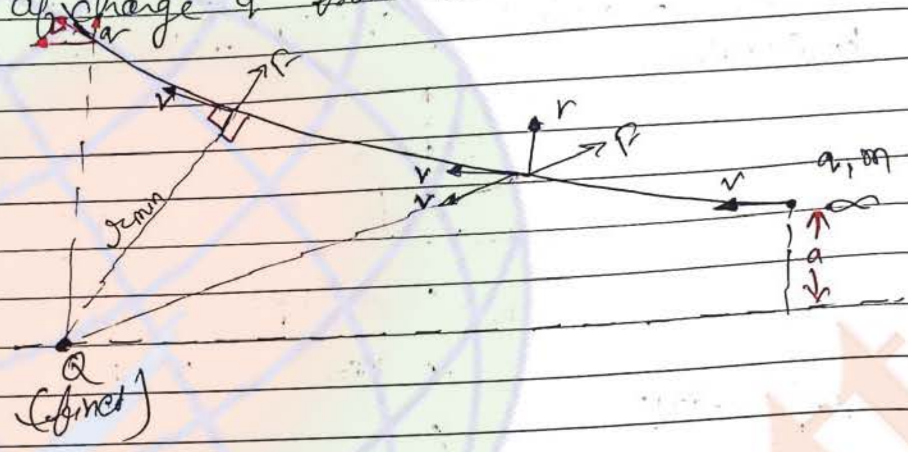
[Eg.]

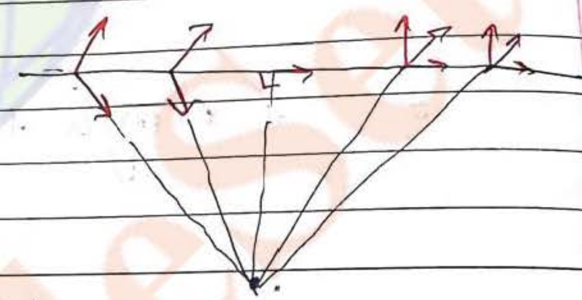
(g neglect)



Determine closest distance of approach of charge "q" from "Q".

Sol^n





$$\frac{1}{2}mv^2 + 0 = \frac{1}{2}mv_1^2 + \frac{kQ \times q}{r_{min}}$$

$\tau_{about\ Q} = 0$

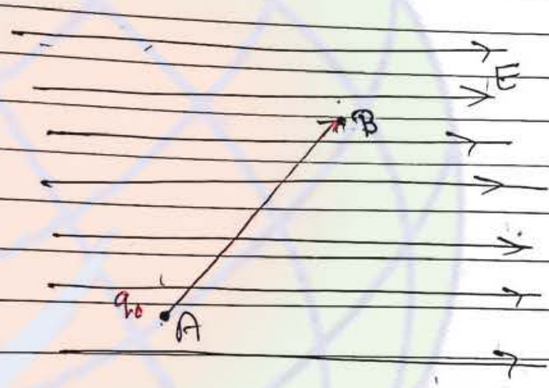
$v \cdot b$ = constant

$mva = mv_1 r_{min}$ —— (2)

Relationship b/w "E" and "V" :-

Case 1st → Uniform "E"

If "E" is known determination of V or ΔV ⇒



$$W_{by\ E.F\ q_0\ A\to B} = -(q_0V_B - q_0V_A)$$

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

$$W_{by\ E.F} = \vec{F}\cdot\vec{AB}$$

$$q_0\vec{E}\cdot\vec{AB} = -q_0(V_B - V_A)$$

$$\boxed{V_B - V_A = -\vec{E}\cdot\vec{AB}}$$

यहाँ ध्यान दें L.H.S और R.H.S में AB, Reverse नहीं हो जाता है|

Attention (v.v.I)

1st Choice

Date / /

i) Potential does not change the direction perpendicular to "E".

ii) In the direction of "E" Potential decrease, whereas the direction opposite to "E" Potential Increase.

Ex 1)

Ex 2) $\vec{E} = 2\hat{i} + 3\hat{j}$

$V_{at}(1,1,1) = 4$ volt

$V_{at}(0,0,0) = ?$

Sol^n

$V_D - V_A = ?$

(A) $V_{at}(1,1,1) = 4$ volt

(D) $V(0,0,0) = ?$

$V_A - V_D = -\vec{E}\cdot\vec{DA}$

$4 - V_D = -(2\hat{i} + 3\hat{j})\cdot(\hat{i}+\hat{j}+\hat{k})$

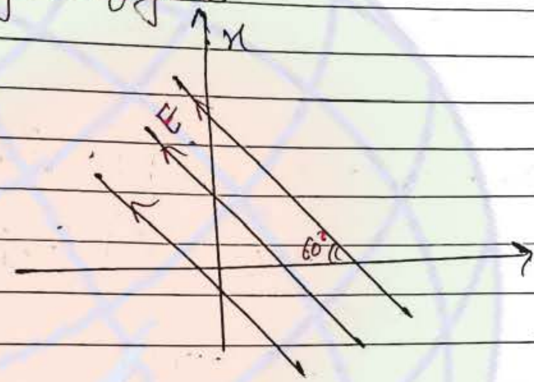
IIT 19

Ex 3

$$4 - V_B = -2 - 3$$

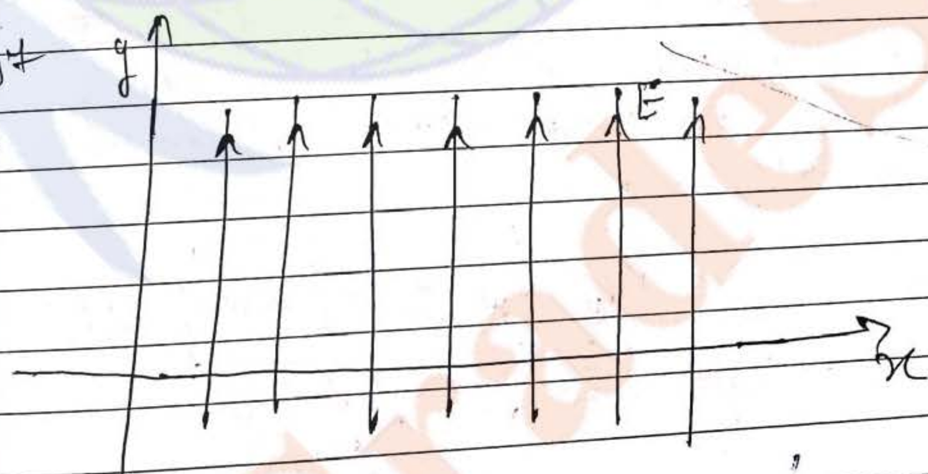
$$V_B = 4 + 2 + 3 = 9V$$

Examiner can give direction of "E" and it's magnitude by making a figure



we can write the "E" in form of vector or ($\hat{i}$, $\hat{j}$, or $\hat{k}$)

IIT 1997 (5.2)



A (9,9)
B (29,0)
C (-39,29)
D (49,49)

Determine workdone by electric force in taking charge "q" from A to B, B to C and C to D

1st Choice

Sol

$$\omega = -\left(P.E_{at\,D} - P.E_{at\,A}\right)$$

$$= -\left(qV_D - qV_A\right)$$

$$= -q\left(V_D - V_A\right)$$

$$V_D - V_A = -\left(E\hat{j}\right)\left(3a\hat{i} + 3a\hat{j}\right)$$

$$= -\left(E\hat{j}\right)\left(3a\hat{i} + 3a\hat{j}\right)$$

$$= -3Ea$$

so,

$$\omega = q \times 3Ea$$

G. Rule

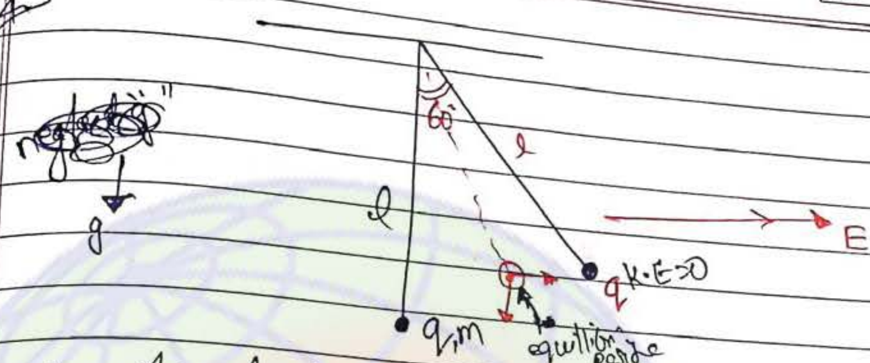
If we need to determine P.D. b/w two points in a electric field and we have not given situation of E.F then use

$$\boxed{V_B - V_A = -\vec{E}\cdot\vec{AB}}$$ this formula to determine potential difference

1st Choice

N.C.E.R.T → 1.1 to 1.9
1.11 to 1.14
Sheet → ... 1, 2, 4,
... 5, 7,
Ex 2 → 21, 20, 19, 18,
Ex 1 → 15, 23, 24, 34, 40
Ex 3 → 9, 12

Ex.



An electric field in horizontal direction is fixed on.

If the max^m angle that the string made with vertical is 60°.

Determine "E".

Sol^n

$$0 + 0 + qV_A = 0 + mg\frac{l}{2} + qV_B$$

$$q(V_A - V_B) = mg\frac{l}{2}$$

1st Choice

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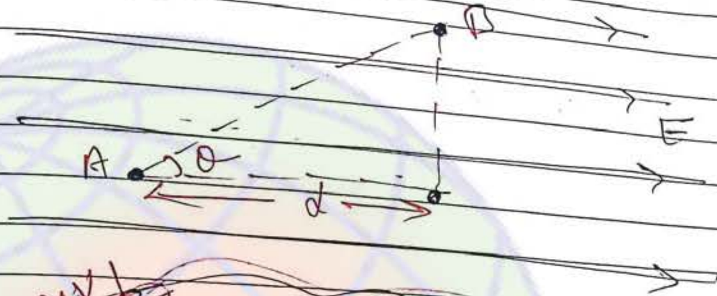
Short Trick: Finding of ΔV if "E" and it's effective seperation is known ⇒



$$\Delta V = \{\} Ed$$

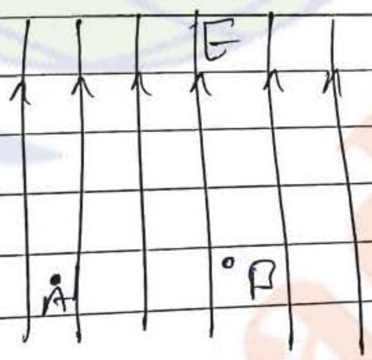
चिह्न लगाना है

E की direction में potential घटता है

d = Distance b/w A and B in the direction of E (effective distance)

$$\because V_B - V_A = -E\, AB \cos\theta = -Ed$$

Q1)



d = 0

Q2)

A(a, 2a)

B(6a, 5a)

d = 5a

$V_B - V_A = -E \times 5a$

GB Imp

जब "$\vec{d}$" निकालना आसान हो और ~~पर~~ तब vector निकालना मुश्किल पड़े

$$V_B - V_A = \vec{E} \times d$$ से निकाल सकते हैं।

Determination of "E" if "V" is known for uniform E →

$$\boxed{E = \frac{\Delta V}{d}}$$

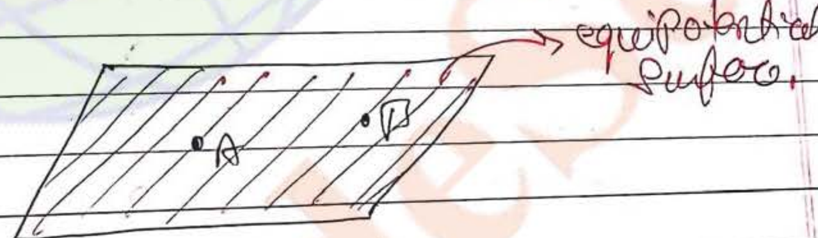
Here

d ⇒ distance b/w two equipotential surface.

ΔV ⇒ Potential difference b/w two equipotential surface

Equipotential Surface →

A hypothetical surface over which potential is same everywhere is known as equipotential surface.



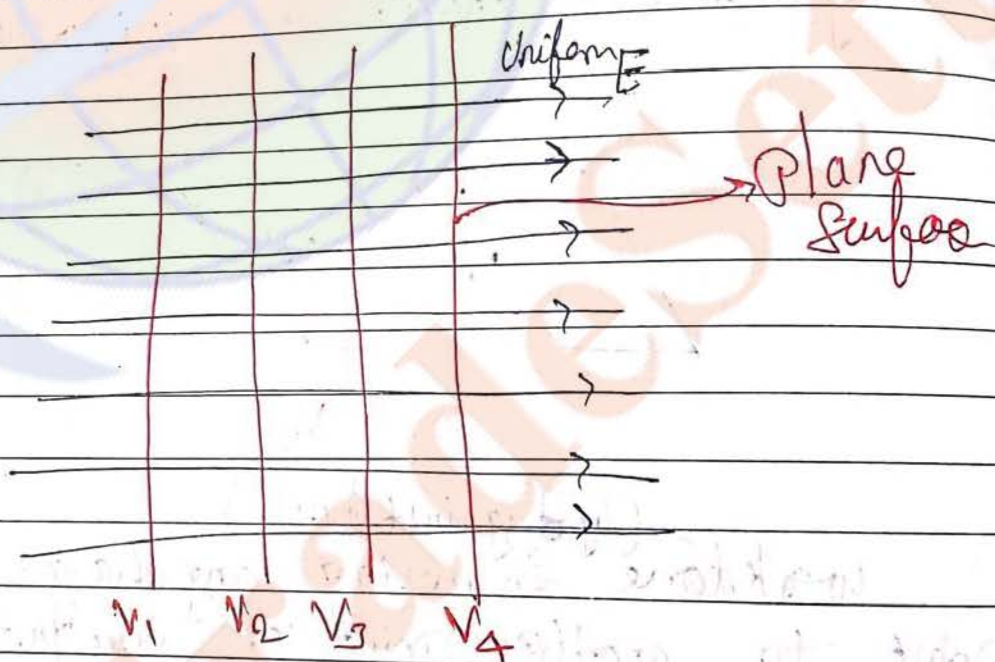
$$V_A = V_B$$

1) workdone (by / against E-Force) in moving any charge from one point to another point on equipotential surface is always zero

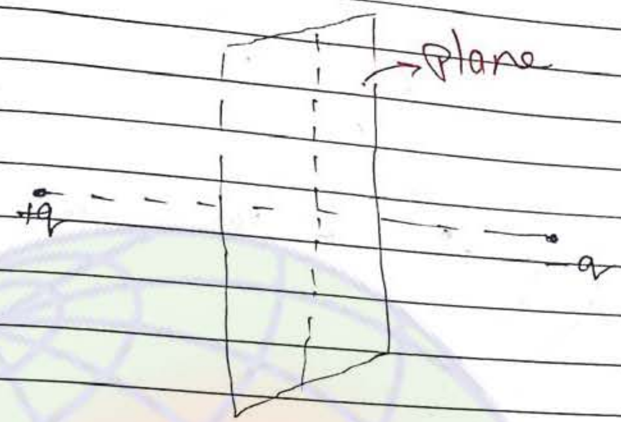
Date / /

11) Equipotential surface is perpendicular to electric field.

eg 1

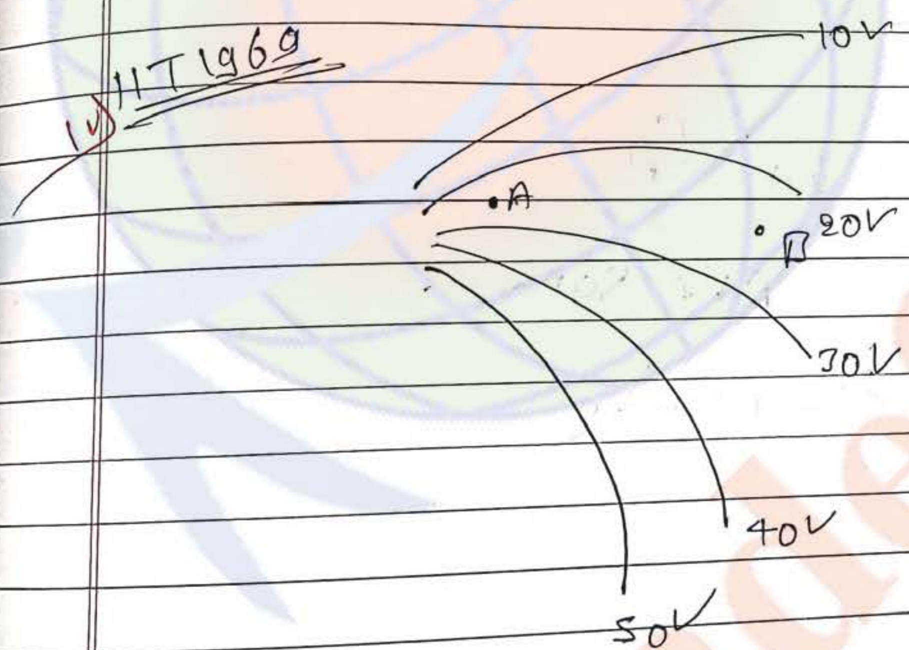


eg2)



iii) Two equipotential surface never Intersect each other.

iv) IIT 1969

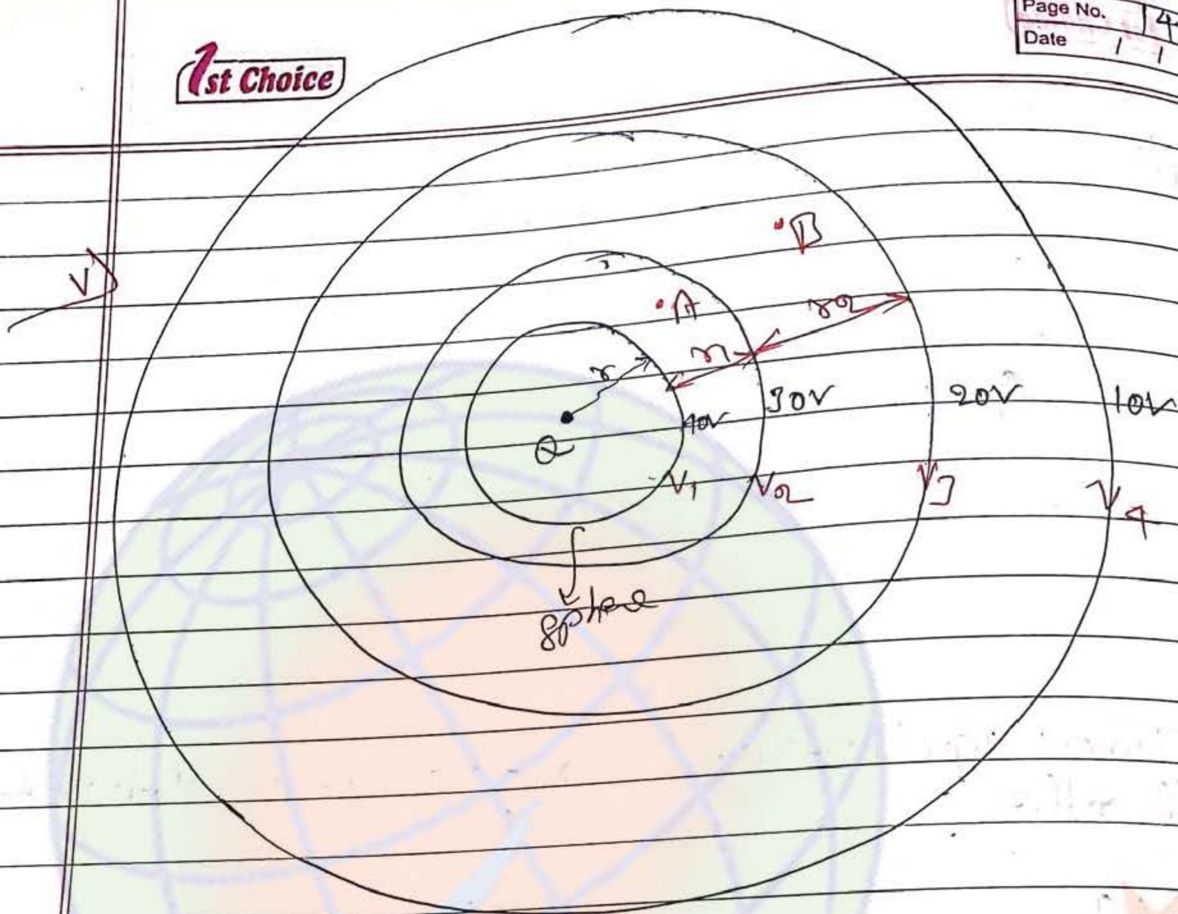


~~$E_A > E_B$~~

$$\boxed{E_A > E_B}$$

ΔV is same but d is less for "A" ~~than~~ in comparision to B

$$E = \frac{\Delta V}{d}$$

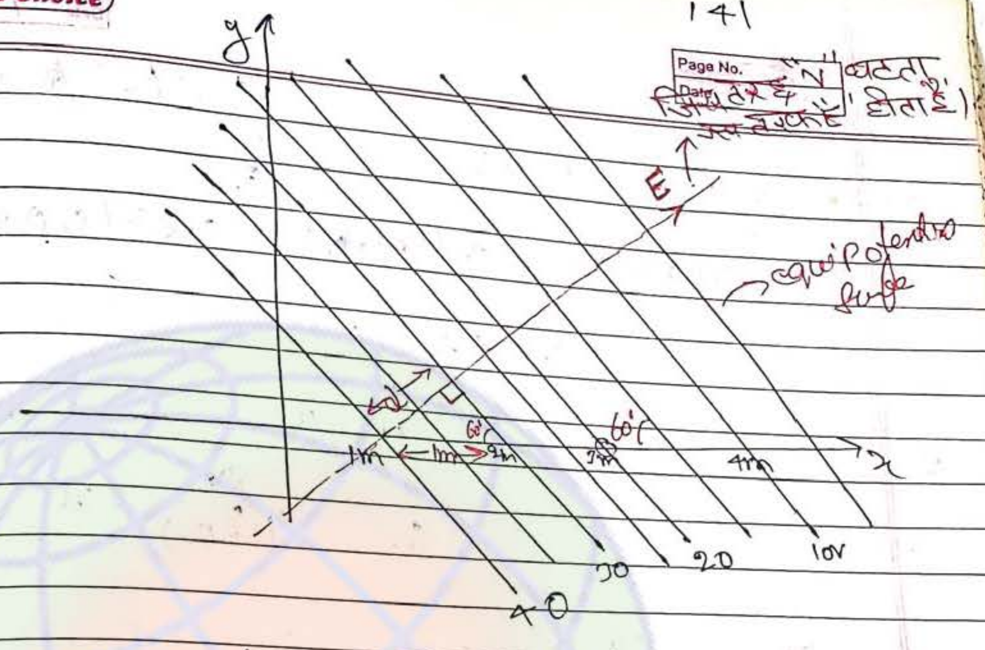


$E_A > E_B$

ΔV is same

$\therefore r_1 < r_2$

Ex.



Determine electric field and it's component.

$$E = \frac{10}{\frac{\sqrt{3}}{2}} = \frac{20}{\sqrt{3}} \quad \because d = \frac{\sqrt{3}}{2}$$

$$E_x = E\cos 30\,\hat{i} = 10\hat{i}$$

$$E_y = E\sin 30\,\hat{j} = \frac{10}{\sqrt{3}}\hat{j} \quad ; \quad E_z = 0$$

Alt:-

shortcut method

$$\vec{E}_x = -\frac{\Delta V_{along\ x}}{\Delta x}\hat{i} = -\left[\frac{10-20}{1}\right]\hat{i} = 10\hat{i}$$

$$\vec{E}_y = -\frac{\Delta V_{along\ y}}{\Delta y}\hat{j} = -\frac{[10-20]}{\sqrt{3}}\hat{j} = \frac{10}{\sqrt{3}}\hat{j}$$

$$\vec{E}_z = -\frac{\Delta V_{along\ z}}{\Delta z}\hat{k}$$

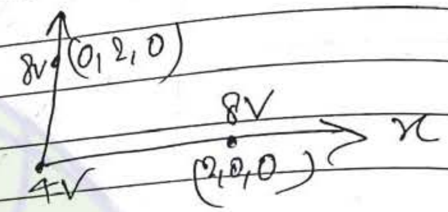
Date / /

$\therefore$ E.F. is uniform

Ex.2 $V(0,0,0) = 4V$

$V(2,0,0)$, $V(0,2,0)$ and $V(0,0,2) = 8V$

$V(4,3,1) = ?$



$$\vec{E}_x = \frac{-(8-4)}{2}\hat{i} = -2\hat{i}$$

$$\vec{E}_y = \frac{-(8-4)}{2}\hat{j} = -2\hat{j}$$

$$\vec{E}_k = \frac{-(8-4)}{2}\hat{k} = -2\hat{k}$$

$$\vec{E} = -2\hat{i} - 2\hat{j} - 2\hat{k}$$

$V(0,0,0) = 4V$, $\qquad V(4,3,1) = ?$

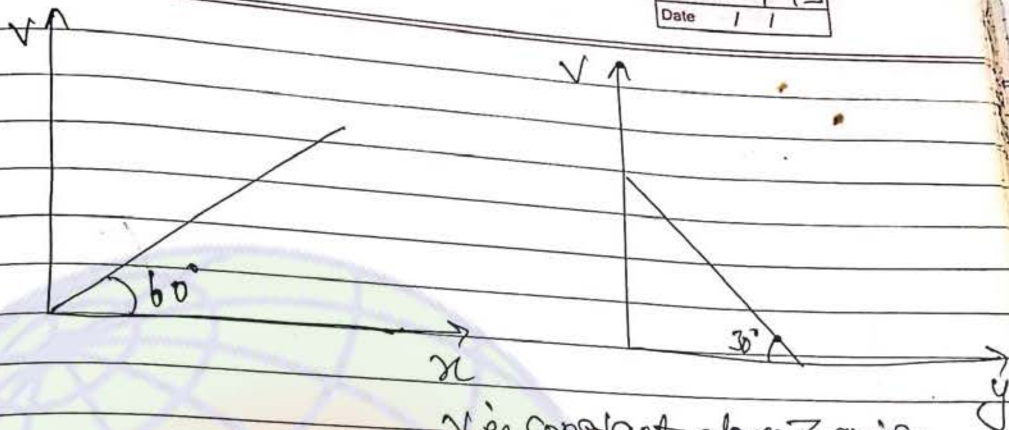
A $\qquad\qquad$ B

$$V_B - V_A = -\left[-2\hat{i} - 2\hat{j} - 2\hat{k}\right]\left[4\hat{i} + 3\hat{j} + 1\hat{k}\right]$$

$$V_B - 4 = 8 + 6 + 2$$

$$V_B = 20V$$

Ex 2.



V is constant along Z-axis.

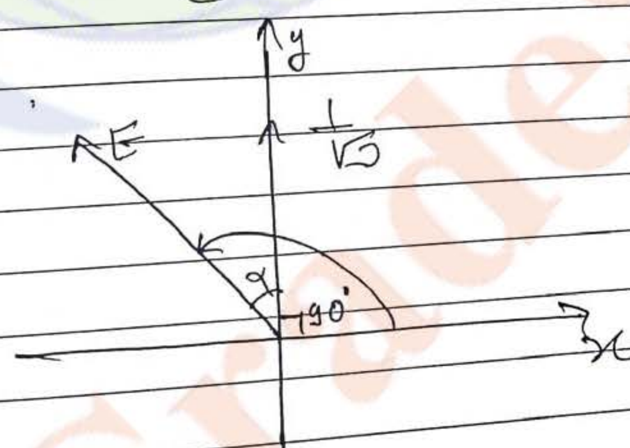
Determine angle of "E" with the x-axis

Sol:
$$E_x = -\frac{dV}{dx}\hat{i}$$

$$= -(\text{slope of } V/x)\hat{i}$$

$$= -(\tan 60)\hat{i} = -\sqrt{3}\hat{i}$$

$$E_y = -(-\tan 30) = \frac{1}{\sqrt{3}}\hat{j}$$



$\Rightarrow 90 + \alpha$

so $90 + \tan^{-1} 3$

$$\tan\alpha = \frac{\sqrt{3}}{1/\sqrt{3}} = 3$$

Relationship b/w "E" and "V" in non-uniform E

Q) $V = x^2yz$

Determine "E" at (1, 1, 1)

Sol^n $\boxed{\vec{E} = \left(-\frac{\partial V}{\partial x}\right)\hat{i} + \left(-\frac{\partial V}{\partial y}\right)\hat{j} + \left(-\frac{\partial V}{\partial z}\right)\hat{k}}$

$= -2xyz\hat{i} - (x^2z)\hat{j} - (x^2y)\hat{k}$

Put, $x = 1$, $y = 1$, $z = 1$

(Q) $V = x^3$

E at $(1, 2, 3) = ?$

$\cancel{\vec{E} = \left(-\frac{\partial V}{\partial x}\right)\hat{i}}$ $\qquad \vec{E} = \frac{-dV}{dx}\hat{i}$

$\cancel{= -3x^2\hat{i}}$ $\qquad = -3x^2\hat{i}$

$\cancel{= -3\hat{i}}$ $\qquad = -3\hat{i}$

Notes → Generalized formula →

$\vec{E} = \frac{-dV}{dx}\hat{r}$

when, $V = f(r)$

VV I

$r = x \qquad \hat{r} \Rightarrow \hat{i}$

$r = y \qquad \hat{r} \Rightarrow \hat{j}$

$r = z \qquad \hat{r} \Rightarrow \hat{k}$

Q.1) $E = (2-3x)\hat{i}$

$V(0,0,0) = 2\text{ volt}$ $\quad V(1,2,3) = ?$

Sol^n $dV = -\vec{E}\cdot\vec{dr}$

$\vec{E} = a\hat{i} + b\hat{j} + c\hat{z}$

$\vec{dr} = dx\hat{i} + dy\hat{j} + dz\hat{k}$

$dV = -(2-3x)\hat{i}\cdot(dx\hat{i} + dy\hat{j} + dz\hat{k})$

$$\int_A^B dV = -\int_0^1 (2-3x)\,dx$$

$$V_B - V_A = -\left[2x\right]_0^1 - \left.\frac{3x^2}{2}\right]_0^1$$

$$V_B = -\frac{1}{2}\text{ volt} + 2$$

$$= \frac{3}{2}$$

Q) $E = x\hat{i} + y\hat{j}$

$V(0,0,0) = 2\text{ volt}$

$V(1,2,3) = ?$

Sol^n Do yourself.

1 47

D.P.P. 3 → 3, 4

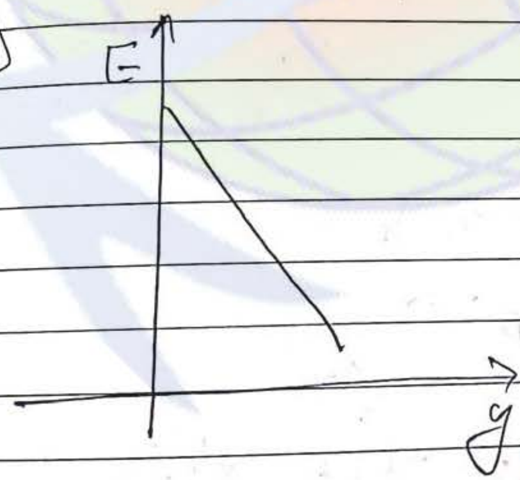
Ex 1 → 29 19, 21, 22

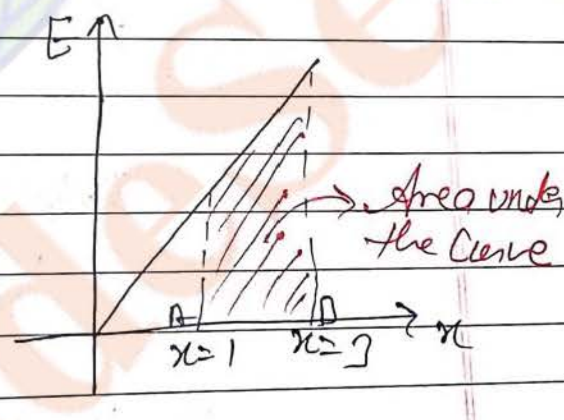
Page No.
Date / /

$$dV = -(x\hat{i} + y\hat{j}) \cdot (dx\hat{i} + dy\hat{j} + dz\hat{k})$$

$$\int_{A}^{B} dV = -\int_{0}^{1} x\,dx - \int_{0}^{2} y\,dy$$

Ex 5





$$\int E_x\,dx$$

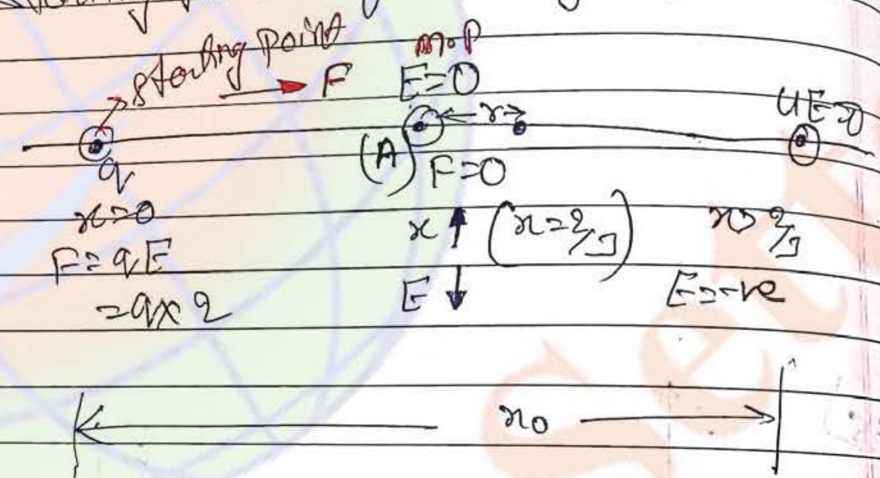
(1, 2, 3) (3, 2, 1)

1st Choice

JEE Adv Example — $E = 2 - 3x$,
A charge particle q is released from rest due to electric field it start moving determine the maximum distance up to which it can move before changing the direction of motion.

Here x is the distance from the starting point of charge "q".

Sol/



$$0 + q \times V_A = 0 + q \times V_B$$

$$V_A - V_B = 0$$

$$V_A - V_B = dV = -\int_0^{x_0} (2-3x)\,dx$$

$$x_0 = \frac{4}{3}$$

At A "q" is in stable equilibrium.

A is mean position, charges ~~os~~ during S.H.M about mean position

$$q\left(2 - 3\left(\frac{q}{3} + v\right)\right) = ma$$

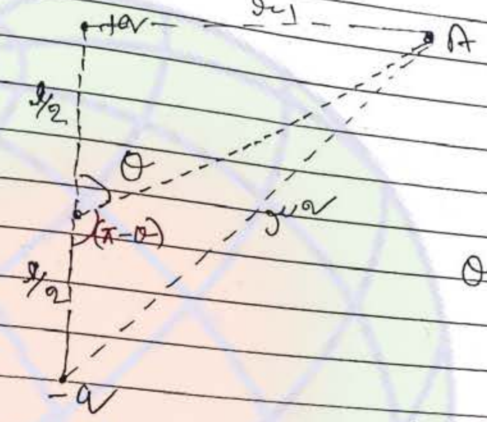
$$\frac{-3xq}{m} = a$$

$$a \propto x$$

1st Choice

Dipole ⇒

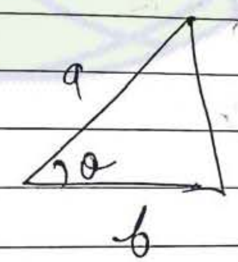
Potential due to dipole



$\theta \Rightarrow \angle \vec{p}$ and $\vec{r}$

$$V_A = \frac{kq}{r_1} - \frac{kq}{r_2}$$

$$= kq\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$



$$\cos\theta = \frac{a^2+b^2-c^2}{2ab}$$

$$c^2 = a^2+b^2-2ab\cos\theta$$

$$r_1^2 = \frac{l^2}{4} + r^2 - 2r \times \frac{l}{2}\cos\theta$$

$$\Rightarrow r^2 - rl\cos\theta = 0$$

$$\frac{1}{r_1} = \left[\frac{1}{r^2 - rl\cos\theta}\right]^{1/2}$$

$$\frac{1}{r_1} = \frac{1}{r}\left[\frac{1}{1 - \frac{l}{r}\cos\theta}\right]^{1/2}$$

$$\frac{1}{r_1} = \frac{1}{r}\left[1 + \frac{l}{2r}\cos\theta\right]$$

$$r_2^2 = \frac{l^2}{4} + r^2 - 2r\frac{l}{2}\cos(\pi-\theta)$$

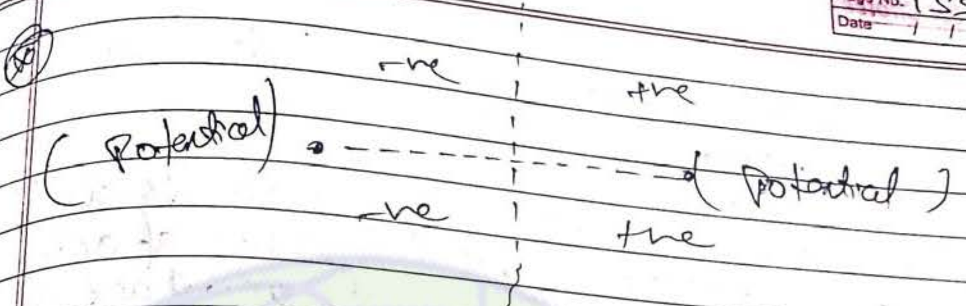
$$r_2^2 = r^2 + rl\cos\theta$$

$$\frac{1}{r_2} = \frac{1}{r}\left[1 - \frac{l}{2r}\cos\theta\right]$$

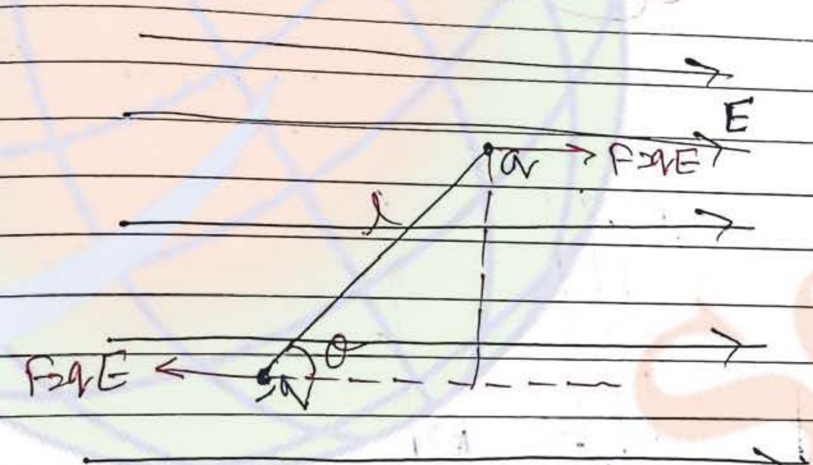
$$\frac{1}{r_1} - \frac{1}{r_2} \Rightarrow \frac{l}{r^2}\cos\theta$$

$$V_A = kq \frac{l}{r^2}\cos\theta$$

$$\boxed{V = \frac{kP\cos\theta}{r^2}}$$



☆ Dipole in uniform external electric field →



1) Net force on a dipole in uniform electric field is always zero.

2) Accⁿ of C.O.M ⇒ Zero
(C.O.M जैसा है वैसा ही रहेगा)
that mean's
C.O.M का रफ़्तार नहीं बदलेगा

state of motion of c.o.m does not change

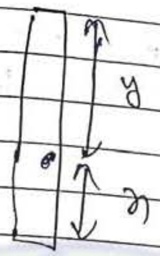
1) Any body acted by two Parallel and opp. forces whose line of action are same experience torque. and this torque is known as couple. and this couple does not depend on the axis.

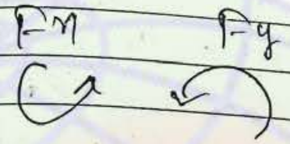
$$\boxed{\text{Couple} = F \times l}$$

Here l > separation b/w l

$F \cdot y$ $F \cdot x$

$$\tau_{net} = Fx - Fy$$
$$= F(x-y)$$
$$= F \cdot l$$





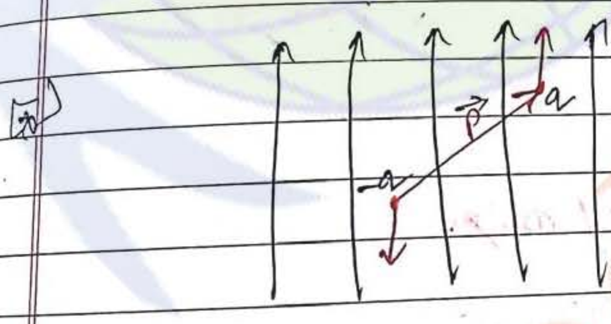
$F(x+y)$

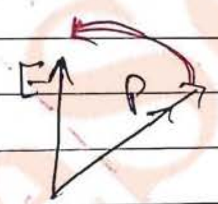
$\Rightarrow Fl$

τ on dipole $= F \times l \sin\theta$

$= qEl\sin\theta$

$\boxed{\tau = pE\sin\theta}$ $\quad \boxed{\because p = ql}$





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

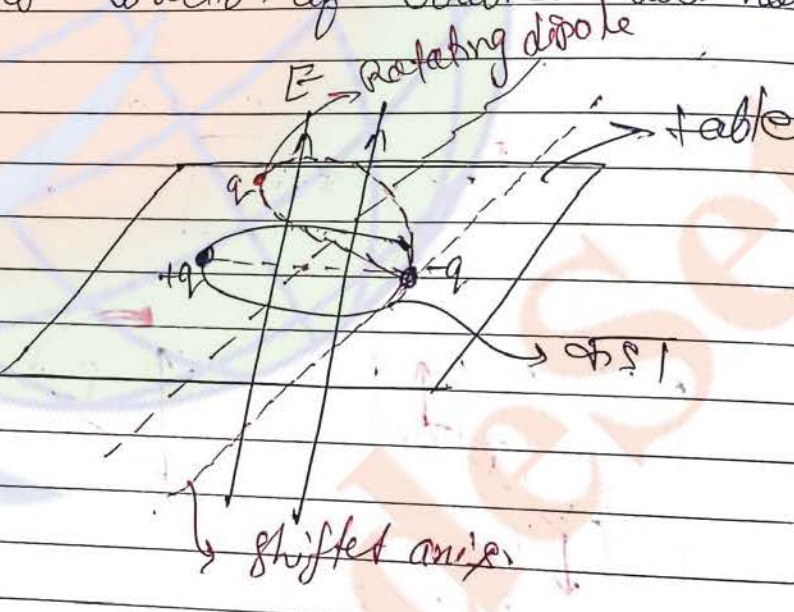
To deter the direction of Rotation

- $\vec{p}$ को $\vec{E}$ की तरफ घुमाओ

4) Dipole rotate about the axis passing through c.o.m and ⊥r to dipole

5) If dipole is not free to rotate about the axis passing through c.o.m than it's rotational axis shift to the new axis, which is parallel to the axis passing through c.o.m

(6) Even after shifting magnitude and direction of couble does not change



$$\tau = PE\sin\theta$$

Rotational axis से Interest का कारण →

$$\tau = F d$$

$$\alpha = \frac{\tau}{I}$$

I = m.o.I about axis dipole is rotating

P.E. of dipole

Interaction energy of dipole in uniform Electric field →

P.E = P.E of −q and P.E of +q

$\Rightarrow -qV_A + qV_B$

$\Rightarrow q[V_B - V_A]$

$\Rightarrow -q\,[El\cos\theta)$

$\boxed{(U) \Rightarrow \text{Potential} = -PE\cos\theta}$

or $\boxed{U = -\vec{P}\cdot\vec{E}} = -PE\cos\theta$

here $\theta \Rightarrow$ Angle b/w $\vec{P}$ and $\vec{E}$.

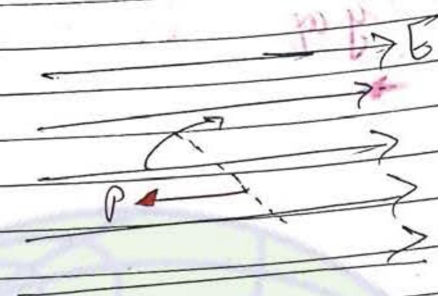
workdone in rotating dipole from one angle to another angle is given by the formula

$W_{by\,E.F} \Rightarrow -(\Delta V)$

$\Rightarrow -[-PE\cos\theta_2 - (-PE\cos\theta_1)]$

$W_{against\,E.F} = +\Delta V$

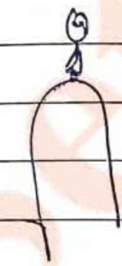
Q.)



on dipole select the ~~wrong~~ right option

A) $F = 0$
B) $\tau = 0$
C) unstable equilibrium
d) stable equilibrium

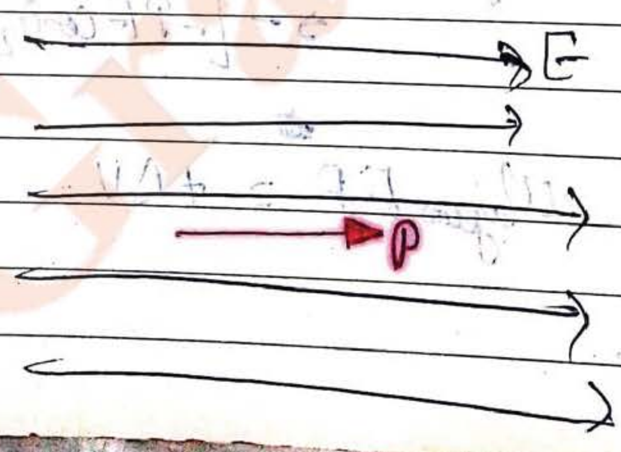
Ans ⇒ A, B, C



$U = -PE\cos\pi$
$= P \cdot E$

(1) In unstable eqn.
P.E is maximum.

Q) Reape the same question in above figure

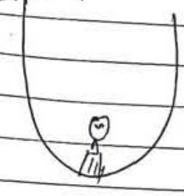


1st Choice

याद रखें ⇒ जब भी कोई dipole, $\vec{E}$ के direction में होगा, उसकी P.E. सबसे कम होगी और ... होगी। उस स्थिति में $F=0, \tau=0$ भी होगा लेकिन unstable eq^m का case होगा।

80/11

A, P, D



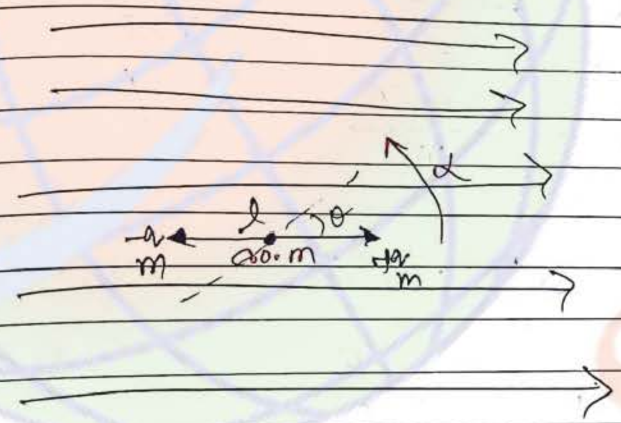
$U = -PE\cos\theta$

$= -PE$

(minimum)

JGG

(8/9.)



Dipole is slightly rotate and then release. Prove that it is oscillating, determine frequency time period.

80/11

$F = ma$

$\tau = I\alpha$

$-qlE\sin\theta = I\alpha$

$-qlE\theta = I\alpha$

$\alpha = \frac{-qlE}{I}\theta$

$$\alpha = \frac{-qlE}{I}\theta$$

$$I = \frac{ml^2}{4} + \frac{ml^2}{4}$$

$$I = \frac{ml^2}{2}$$

$$\alpha = \frac{-qlE \times 2\theta}{ml^2}$$

S.H.M

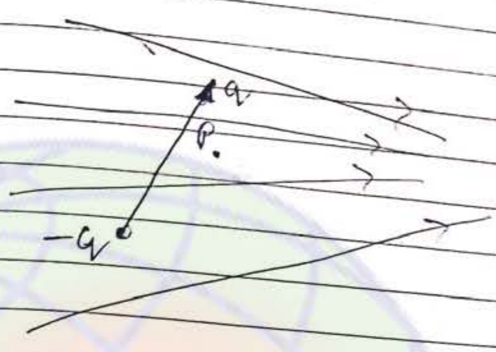
$$\alpha = \frac{-2qE\theta}{ml}$$

$$\alpha = -\omega^2\theta$$

$$\omega = \sqrt{\frac{2qE}{ml}}$$

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

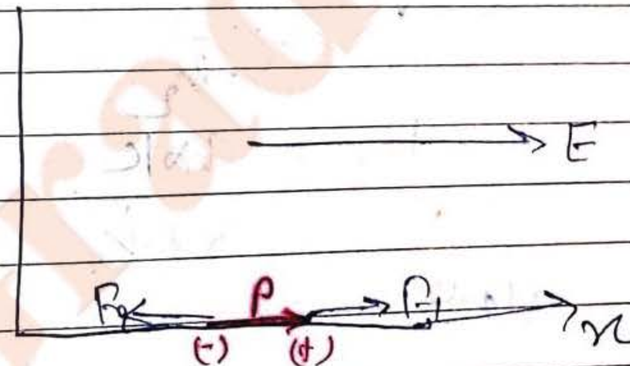
Dipole in non-uniform E →



* No रटना for force and torque because anything is possible.

* we don't have any formula here for force or torque in the dipole.

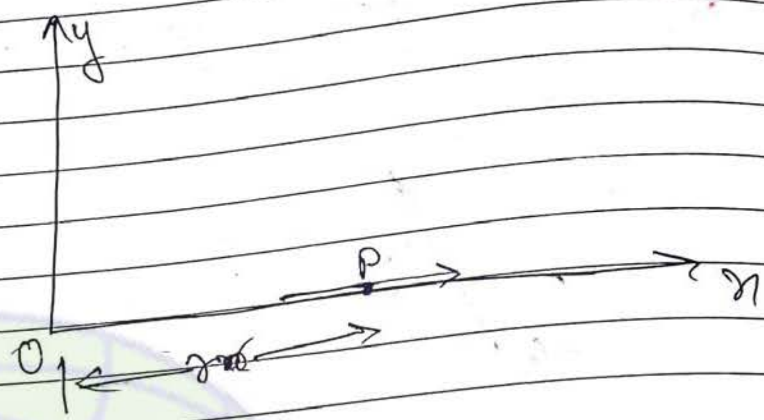
Ex) An electric field is in the x-direction and it's magnitude is increase in the x-direction determine the direction of force on dipole.



$F_1 > F_2$

$F_{net} \Rightarrow$

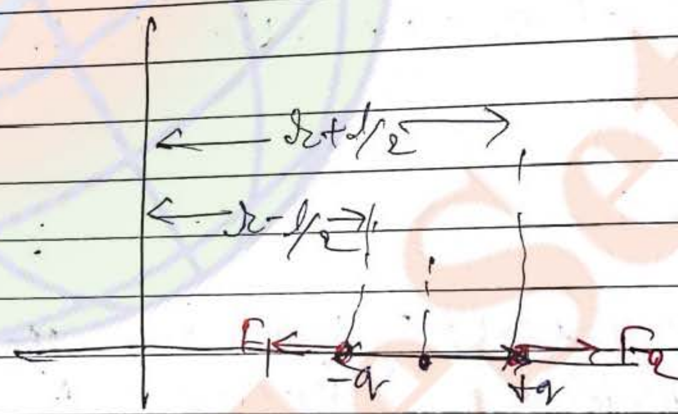
(iv)



$E = \frac{k}{x}$

x → distance of the x-axis from
Determine the force on dipole
(when dipole is short dipole)

sol^n



$F_1 = \frac{q \times k}{r - l/2}$

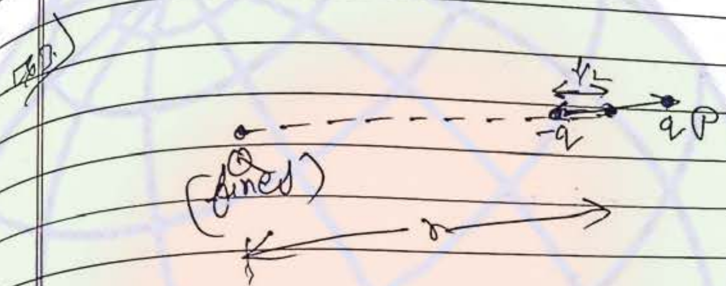
$F_2 = \frac{q \times k}{r + l/2}$

Now

$$F_{net} = F_1 - F_2 = kq\left[\frac{1}{r-l/2} - \frac{1}{r+l/2}\right]$$

$$= \frac{kql}{r^2 - \frac{l^2}{4}} = \frac{kP}{r^2}\left(-\hat{i}\right)$$

Q.



Determine dipole P.E. with respect to point charge "q"

Sol.

Potential energy $= U = -q \times V_A + qV_B$

$$= \frac{-q \times kQ}{r-l/2} + \frac{q \times kQ}{r+l/2}$$

$$\Rightarrow kQ \times q\left[\frac{1}{r+l/2} - \frac{1}{r-l/2}\right]$$

$$\boxed{U = -\frac{kQP}{r^2}}$$

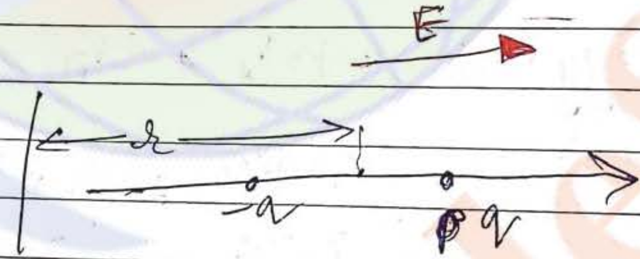
Note:
Even in non-uniform E.F, P.E of dipole can be determine by the formula $-PE\cos\theta$ where E is the Electric field Intensity at the location of centre of dipole.

$$U = -PE\cos\theta$$

$$= \frac{-PKQ\cos\theta}{r^2}$$

$$= \frac{-KQP}{r^2}$$

Examina can ask energy conservation type of ~~also~~ problem also.

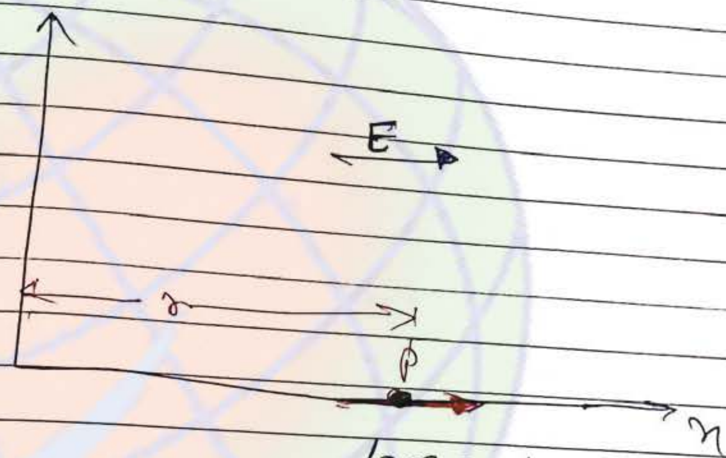


$$F dr = -dU$$

$$F = -\frac{dU}{dr}$$

Note (Advice) $\Rightarrow$

If we will able to determine direction of force along certain axis then we can use the formula $\boxed{F = -\frac{du}{dr}}$ for determination of force on dipole.



fore on dipole

$F = -\frac{dy}{dr}$

$Fdr = -dy$

$F = -\frac{dy}{dr}$

$U = -PE\cos\theta$

$= -\frac{PK}{r}\cos\theta \Rightarrow \frac{-KP}{r}$

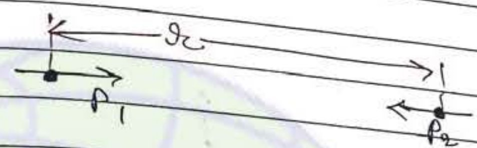
$F = -\frac{dy}{dr} \Rightarrow \frac{-KP}{r^2}$

Here

-ve sign Indicate that assumed direction of force is reversed (wrong)

JEE ★ Interaction b/w dipoles →

Example:–



Determine Interaction energy b/w the dipole.
P.E

Step 1st →
Determine $\vec{E}$ at location of one dipole due to other dipole

Step 2nd →
Use formula $U = -PE\cos\theta$

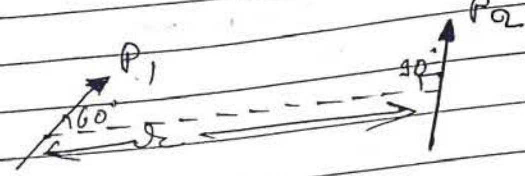
Sol/n
Step 1st →

$$E = \frac{2KP_2}{r^3}$$

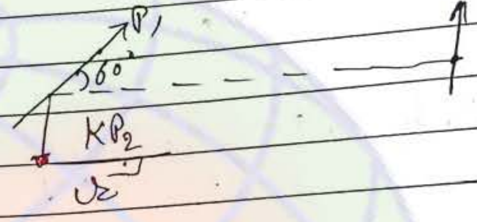
Now

Step 2nd →
$$U = -PE\cos\theta$$
$$= -P_1\frac{2KP_2\cos\pi}{r^3}$$
$$= +\frac{2KP_1P_2}{r^3}$$

Sol)



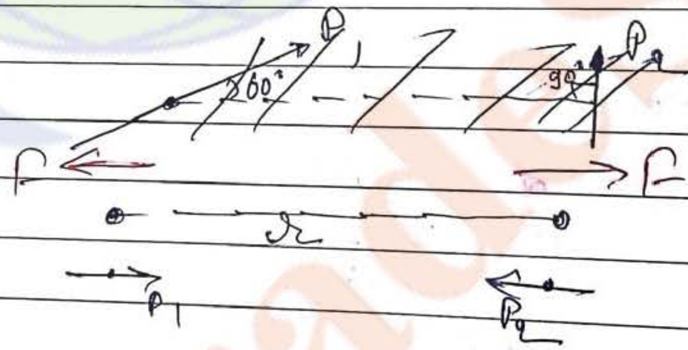
Sol^n



$$U = -kP_1 \times \frac{kP_2}{r^3}\cos(90+60)$$

$$= \frac{kP_1P_2}{r^3}\frac{\sqrt{3}}{2}$$

(Q) Determine force b/w two dipole?



Sol^n

Sol^n step 1st

$$F = \frac{2kP_2}{r^3}$$

Step 2nd → $U = -PE\cos\theta$

$$= -P_1\frac{2kP_2}{r^3}\cos\pi$$

$$= \frac{2KP_1P_2}{r^3}$$

$$F dr = -\frac{du}{dr}$$

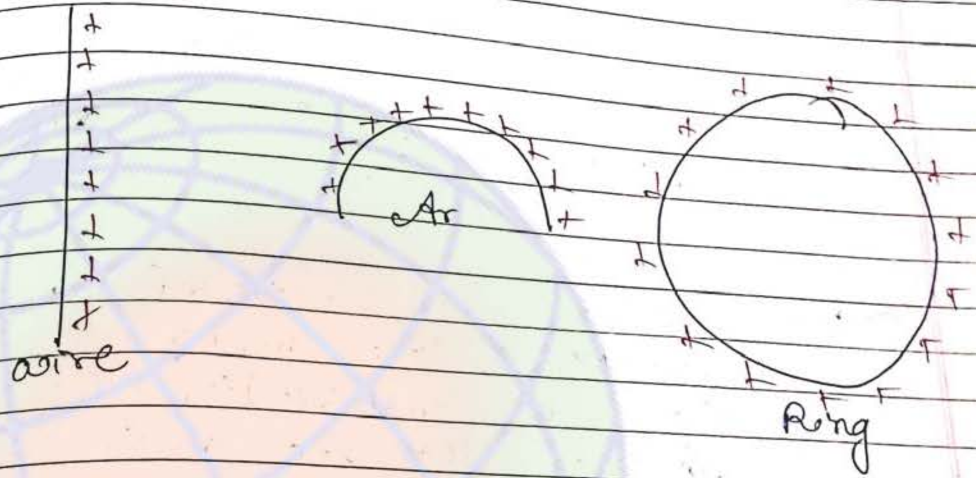
$$= \frac{+6KP_1P_2}{r^4}$$

Note ⇒
If dipole is very short we can use formula of torque $PE\sin\theta$ even if it non uniform

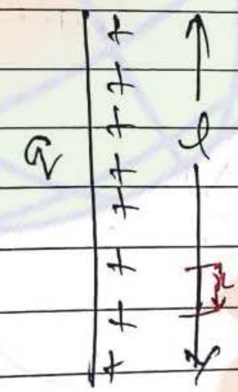
Extended charge configuration

बड़े सुवतान (बड़े आकुट)

1) Line charge ⇒



λ = linear charge density (charge per unit length)



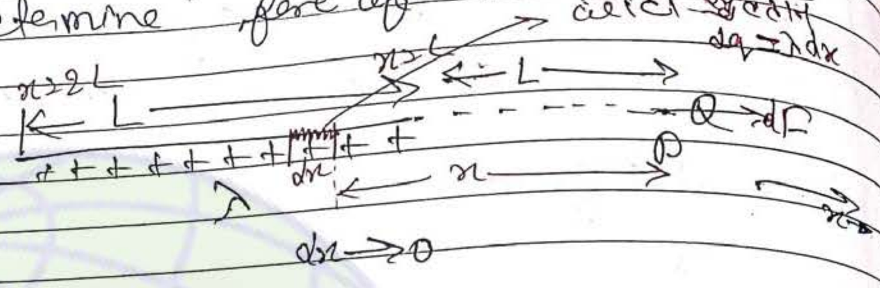
$$\lambda = \frac{q}{l}$$

charge on $x = \lambda x$

* line charge can be assumed as they are consist of large number of छोटे सुवतान (point elements)

1st Choice

Ex) Determine force of "Q"



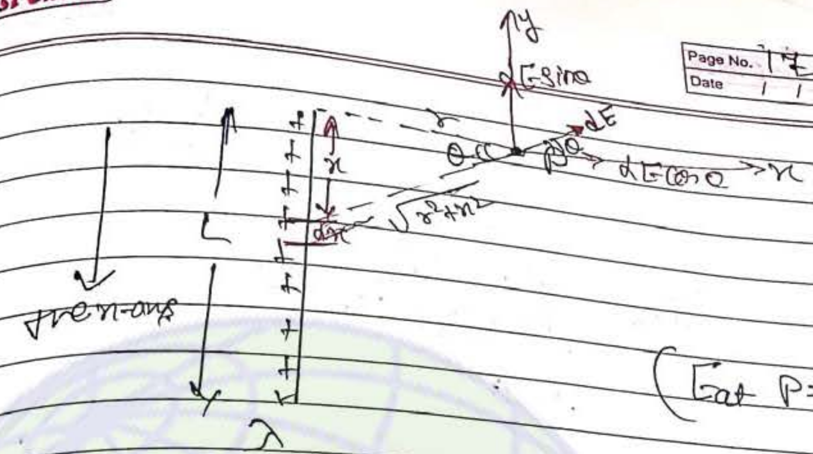
$$dF = \frac{1}{4\pi\varepsilon_0}\frac{dq \times Q}{x^2} = \frac{KQ\lambda dx}{x^2}$$

* Force due to each element in is the same direction. ~~Here~~ Therefor we can do (simple addition) or (सीधा जोड़ addn) because they are in the direction.

So Integration:-

$$\int_{x=a}^{x=b} f(x)\,dx = f(a)\,dx + f(a+dx)\,dx + f(a+2dx)\,dx + \ldots$$

$$F = \int_{x=L}^{x=2L} \frac{KQ\lambda dx}{x^2}\,\hat{i}$$



(E at P = ?)

Determine "E" at P.

$$dq = \lambda dx$$

$$dE = \frac{k\,dq}{x^2+r^2}$$

Direction of "E" due to each element is in different direction therefore बीजीय addition can not be done

we will take two component's of dE

$$dE_x = dE\cos\theta\,\hat{i} \Rightarrow$$

$$dE_y = dE\sin\theta\,\hat{j}$$

$$dE_x = \frac{k r\,dq}{(x^2+r^2)^{3/2}}\hat{i}$$ (सादृश function)

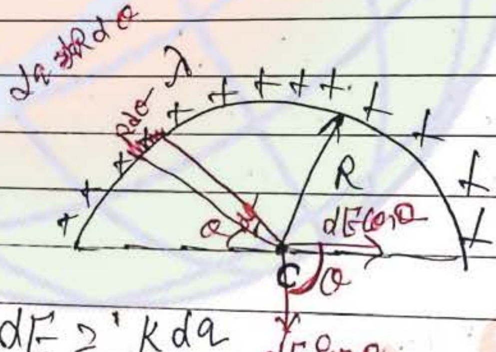
$$dE_y = \frac{k x\,dq}{(x^2+r^2)^{3/2}}\hat{j}$$

$\cos\theta = \frac{r}{(r^2+x^2)^{3/2}}$, $\sin\theta = \frac{x}{(x^2+r^2)}$

$$E_x = \int dE_x = \int_{x=0}^{x=L} \frac{k x \lambda dx}{(x^2+r^2)^{3/2}} \hat{j}$$

$$E_y = \int dE_y = \int_{x=0}^{x=L} \frac{k x \lambda dx}{(x^2+d^2)^{3/2}}$$

Ex) Half Rings



E at C = ?

$dE = \frac{k\,dq}{r^2}$

$= \frac{k\lambda R d\theta}{R^2}$, $dE = \frac{k\lambda d\theta}{R}$

Directional of dE due to each element is different.

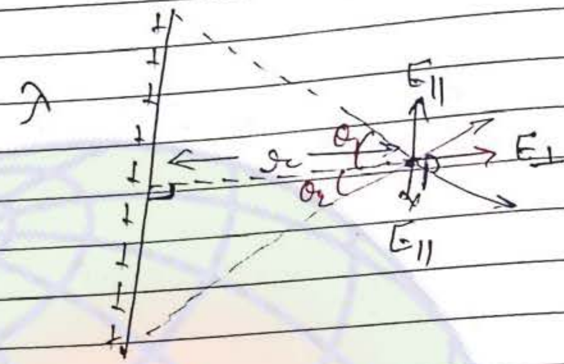
Therefore we have to take components of dE.

$$E_x = \int_0^{\pi} \frac{k\lambda \cos\theta \, d\theta}{R} = 0$$

$$dE_y = \frac{k\lambda \sin d\theta(-\hat{j})}{R} dE = \frac{k\lambda d\theta}{R}$$

$$E_y = \int_0^{\pi} \frac{k\lambda}{R} \sin\theta \, d\theta(-\hat{j})$$

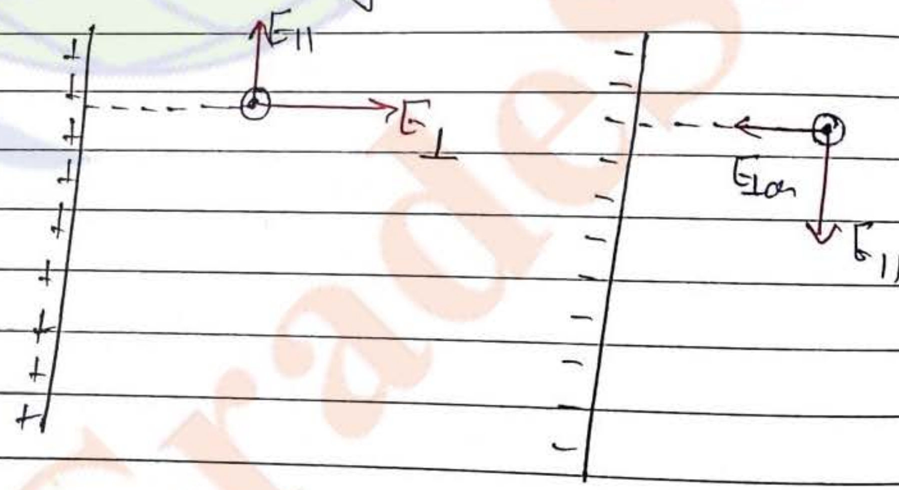
E due to uniformly charged wire →



$$\boxed{E_{\perp} = \frac{\lambda}{4\pi\varepsilon_0 r}\left[\sin\theta_1 + \sin\theta_2\right]}$$

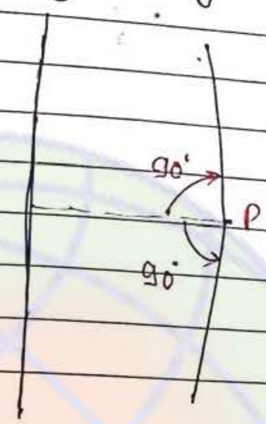
$$\boxed{E_{\parallel} = \frac{\lambda}{4\pi\varepsilon_0 r}\left|\cos\theta_1 - \cos\theta_2\right|}$$

Note: λ with its sign.



Result's :-

1) E for Infinitly large wire :-



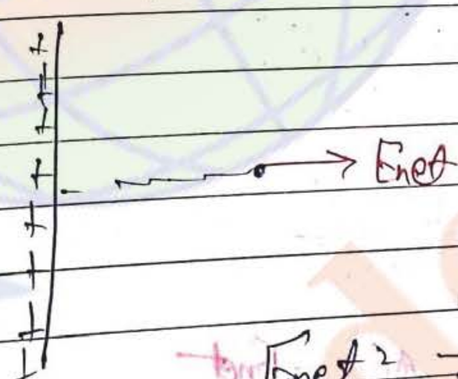
$\theta_1 = \theta$

$(\theta_1 = \theta_2 = 90)$

$$E_{\perp} = \frac{\lambda}{2\pi\epsilon_0 r}$$

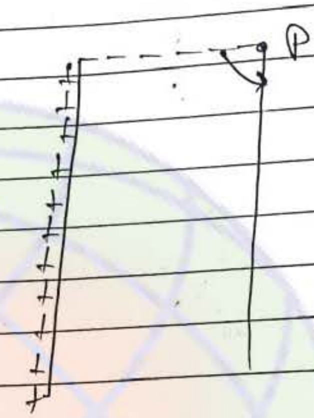
$$E_{\parallel} = 0$$

Notes-



$$E_{net} = \frac{\lambda}{2\pi\epsilon_0 r}$$

2.) E for semi ~~inf~~ Infinite large wire



$\theta_1 = 0$

$\theta_2 = \pi/2$

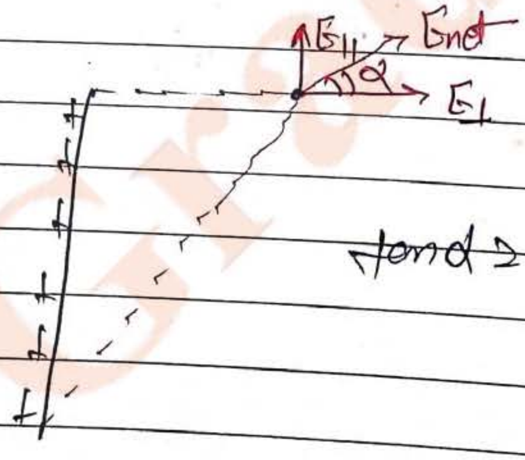
$$E_\perp = \frac{\lambda}{4\pi\varepsilon_0 d}$$

$$E_{\parallel} = \frac{\lambda}{4\pi\varepsilon_0 d}$$

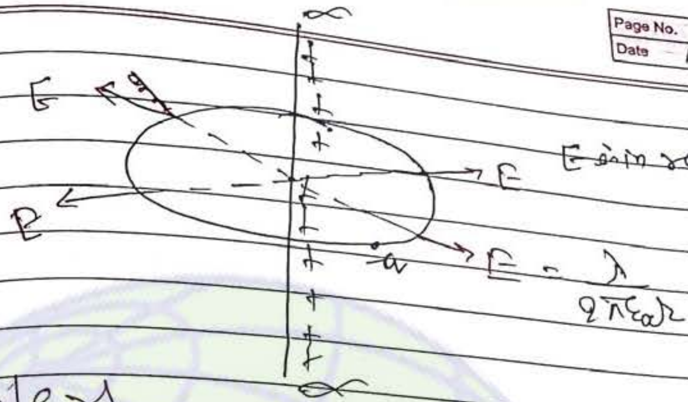
$$E_{net} = \sqrt{E_\perp^2 + E_\parallel^2}$$

$$= \frac{\sqrt{2}\,\lambda}{4\pi\varepsilon_0 d}$$

Note ⇒



$$\tan\alpha = \frac{E_\parallel}{E_\perp}$$



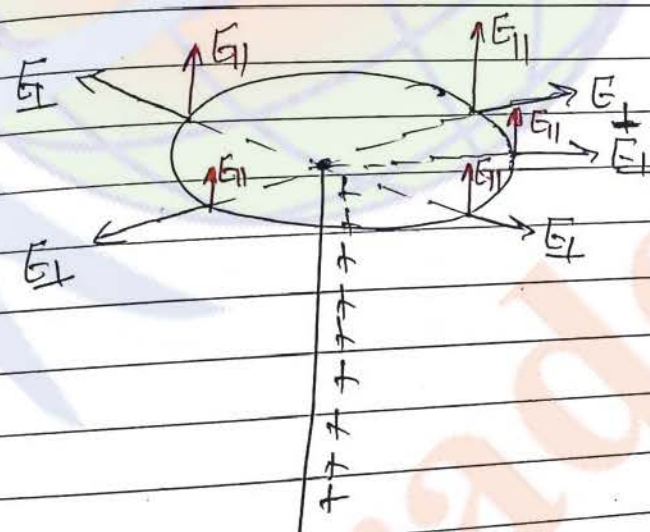
E is in radial direction.

Notes

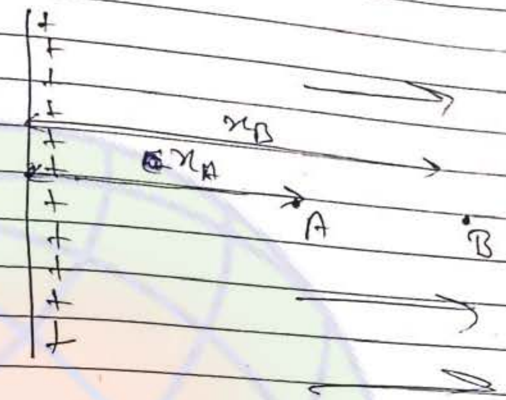
① As each radial therefor any charge placed near this wire experience radial forces.

Therefore examiner can ask question of circular motion

where centripetal force is provided by electric force (qE)



Potential difference due to uniformly charge wire →



$$E = \frac{\lambda}{2\pi\varepsilon_0 x} \text{ or } \frac{\lambda}{2\pi\varepsilon_0 x}\hat{i}$$

Non-uniform E

$$dV = -\vec{E}\cdot d\vec{l}$$

$$= \frac{-\lambda}{2\pi\varepsilon_0 x}\hat{i}\left(dx\hat{i} + dy\hat{j} + dz\hat{k}\right)$$

$$\int_A^B dV = \int_{x_A}^{x_B} \frac{-\lambda}{2\pi\varepsilon_0 x}\,dx$$

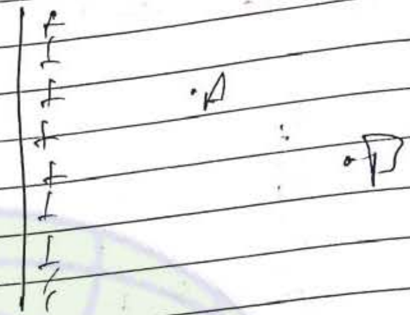
$$\boxed{V_B - V_A = \frac{-\lambda}{2\pi\varepsilon_0}\ln\frac{x_B}{x_A}}$$ λ with sign.

$x_B \Rightarrow \perp r$ distance of B from wire.

$x_A \Rightarrow \perp r$ distance of A from wire.

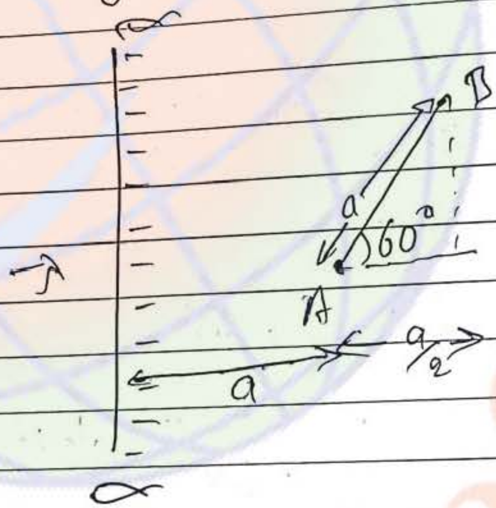
1st Choice

Note



(formula need charg)

Ex) Determine work done by the Electric force in moving charge $(-q)$ from B to A.



Sol^n

$-(V_f - V_i)$

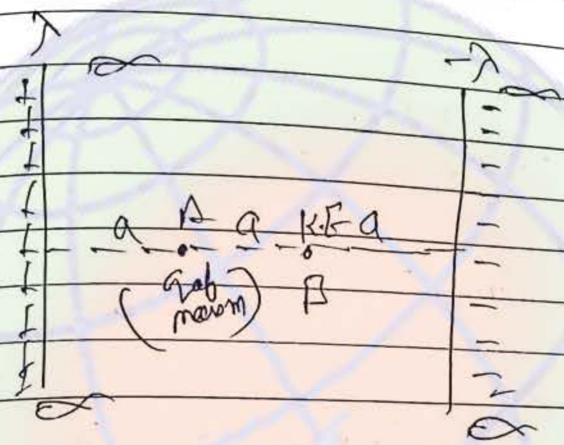
$-(qV_A - qV_B) = -q(V_A - V_B)$

$= -q\left[\frac{-(-\lambda)}{2\pi\varepsilon_0} \ln \frac{a \times 2}{3a}\right]$

$= \frac{-q\lambda}{2\pi\varepsilon_0} \ln \frac{2}{3}$

So,

$V_D - V_A =$



Charge "q" of mass "m" is released from rest at point "A". Due to electric force it starts moving toward's "B". Determine it's velocity when it reach at B.

Sol/ $qV_A = qV_B + \frac{1}{2}mv^2$

$q(V_A - V_B) = \frac{1}{2}mv^2$

Concept ⇒

~~Whenever wires~~

Whenever we have given two or more than two wire then to determine P.D b/w of any two point's first determine P.D due to individual wires and then add them ~~vectorially~~ algebrically

$$\Delta V_{+\lambda} = \frac{-\lambda}{2\pi\varepsilon_0} \ln \frac{a}{2a}$$

$$= \frac{-\lambda}{2\pi\varepsilon_0} \ln \frac{1}{2} = \frac{\lambda}{2\pi\varepsilon_0} \ln 2$$

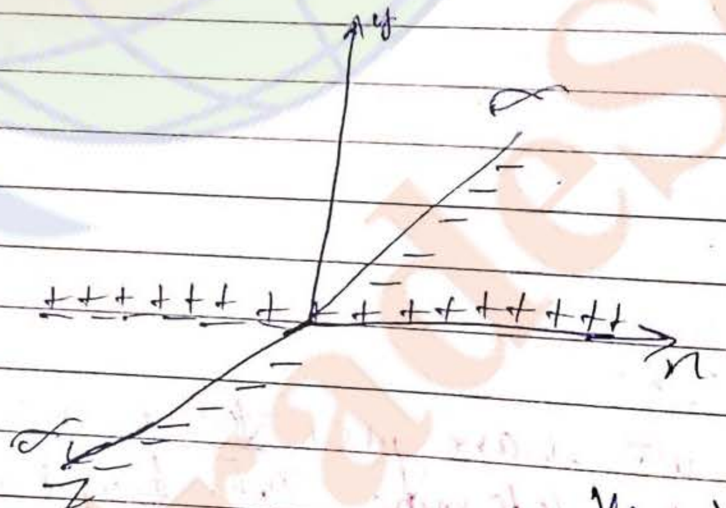
$$\Delta V_{-\lambda} = \frac{-(-\lambda)}{2\pi\varepsilon_0} \ln \frac{2a}{a}$$

$$\Rightarrow \frac{\lambda}{2\pi\varepsilon_0} \ln 2$$

$$V_A - V_B = \frac{\lambda}{2\pi\varepsilon_0} \ln 2 + \frac{\lambda}{2\pi\varepsilon_0} \ln 2$$

$$= \frac{\lambda}{\pi\varepsilon_0} \ln 2$$

(x, y, ...)



A(2, 1, 2)

B(1, 2, 3)

$V_A - V_B = ?$

$$\Delta V_A = \frac{-\lambda}{2\pi\varepsilon_0} \ln \frac{x_A}{x_B}$$

Also

$$\Delta V_{\lambda+} = \frac{-\lambda}{2\pi\varepsilon_0} \ln \frac{x_A}{x_B}$$

Perpendicular on x-axis from (x_1, y_1, z_1)

$$= \sqrt{y_1^2 + z_1^2}$$

$$x_A = \sqrt{1^2 + 2^2} = \sqrt{5}$$

$$x_B = \sqrt{4+9} = \sqrt{13}$$

$$\Delta V_{\lambda+} = \frac{-\lambda}{2\pi\varepsilon_0} \ln \frac{\sqrt{5}}{\sqrt{13}}$$

$$= \frac{-\lambda}{2\pi\varepsilon_0} \ln \sqrt{\frac{5}{13}}$$

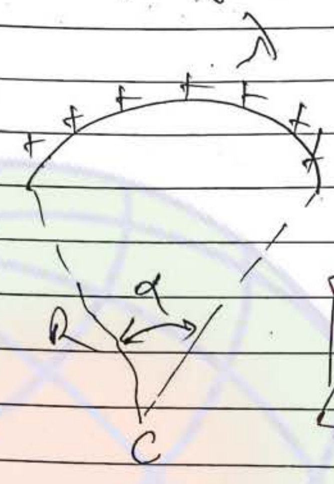
$$\Delta V = \Delta V_{-2\lambda} + \Delta V_{+\lambda}$$

$$\Delta V = 0 - \frac{\lambda}{2\pi\varepsilon_0} \ln \sqrt{}$$

Note →

Examiner can ask question of workdone as well as motion and energy conservation in extended body.

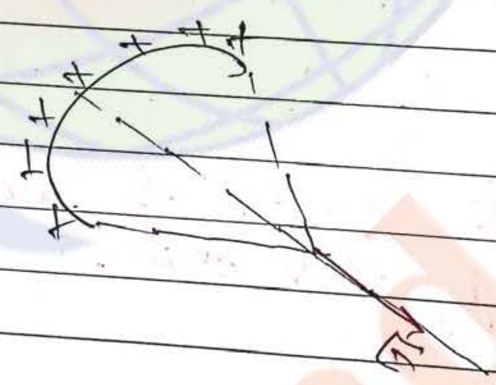
E due to uniformly charged arc

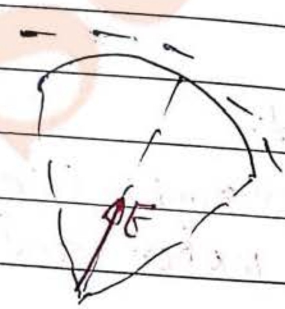


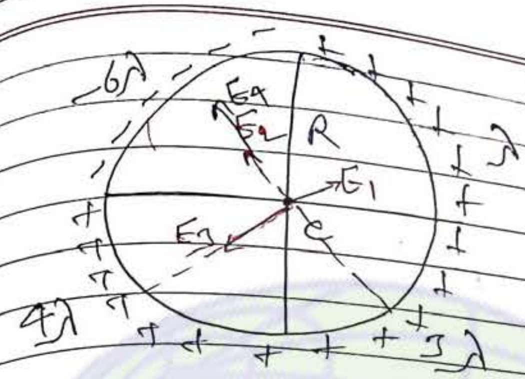
$$\boxed{E_{\text{at centre}} = \frac{\lambda \sin \alpha/2}{2\pi\varepsilon_0 R}}$$

λ without sign
R → radius of arc

(8) Direction of E →
E is along the angle bisector of arc







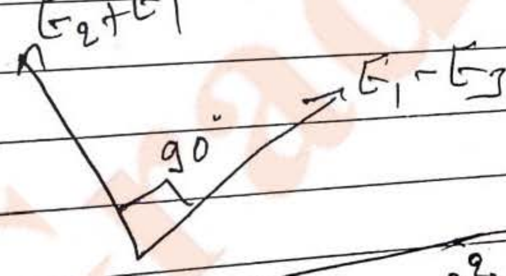
$E_{at\ C} = ?$

$E_{\lambda} = \frac{\lambda}{2\pi\varepsilon_0 R}$, $E_1 = E_{4\lambda} = \frac{4\lambda}{2\pi\varepsilon_0 R}$

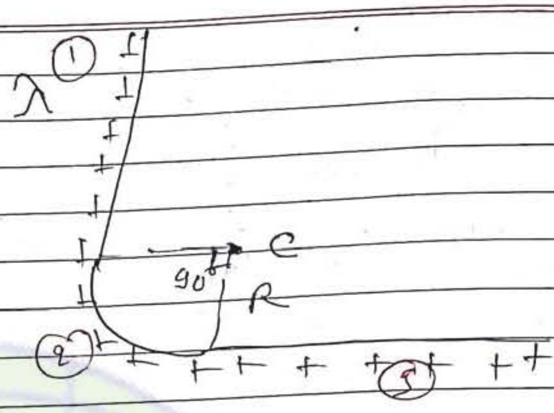
$E_{3\lambda} = \frac{3\lambda}{2\pi\varepsilon_0 R}$, $E_{-6\lambda} = \frac{-6\lambda}{2\pi\varepsilon_0 R}$

$E_1 = \frac{4\lambda \sin\frac{90}{2}}{2\pi\varepsilon_0 R}$, $E_3 = \frac{\lambda \sin\frac{90}{2}}{2\pi\varepsilon_0 R}$

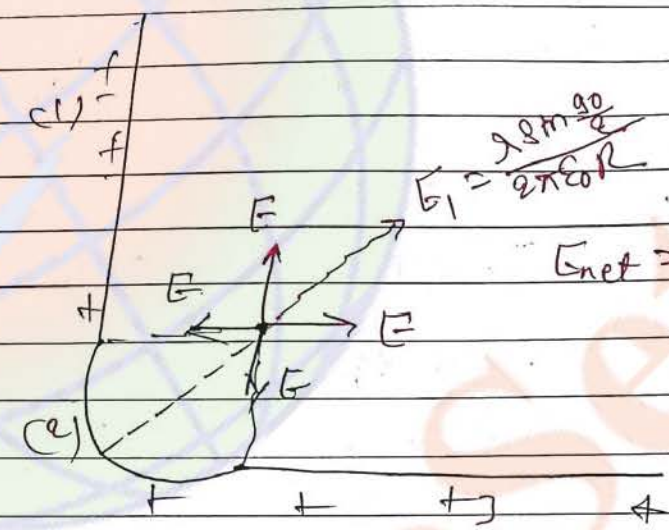
$E_2 = \frac{3\lambda \sin\frac{90}{2}}{2\pi\varepsilon_0 R}$, $E_4 = \frac{6\lambda}{2\pi\varepsilon_0 R} \sin 90/2$



$$E_{net} = \sqrt{(E_2 + E_4)^2 + (E_1 - E_3)^2}$$



Radius of R is very small in comparison to length of wires.
Determine "E" at C.



$$E_1 = \frac{\lambda \sin\frac{90}{2}}{2\pi\varepsilon_0 R}$$

$$E_{net} = E_1$$

eg

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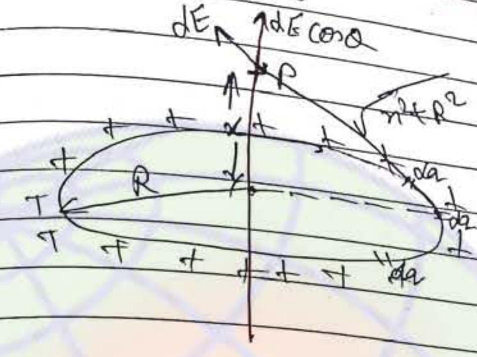
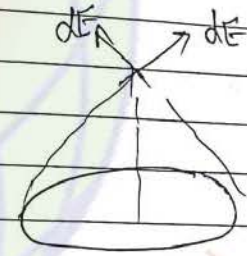
E due to Uniformly charge ring on any point at it's axis



Q = charge on ring

Direction of dE due to each sultan is different



Therefore we have to take components of dE.

Component's of dE

Along the axis | Perpendicular to axis

$dE_{axis} = dE\cos\theta$

$= \frac{k\,dq}{(x^2+R^2)} \cdot \frac{x}{(x^2+R^2)^{1/2}}$

$dE_{\perp}$ to axis. By symmetry this component cancel out.

$dE_{axis} = \frac{kx\,dq}{(x^2+R^2)^{3/2}}$

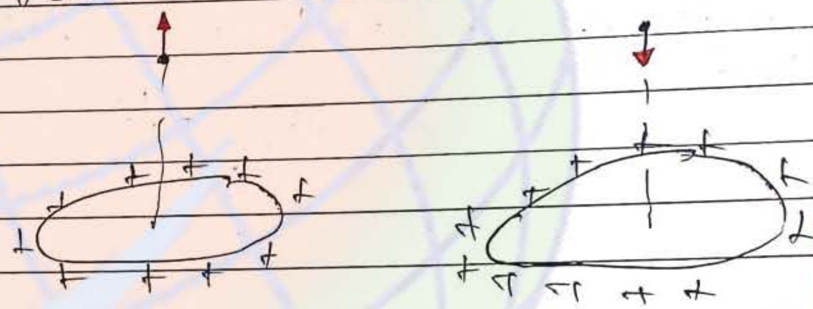
Date / /

$$E_{net} = \int dE_{axis}$$

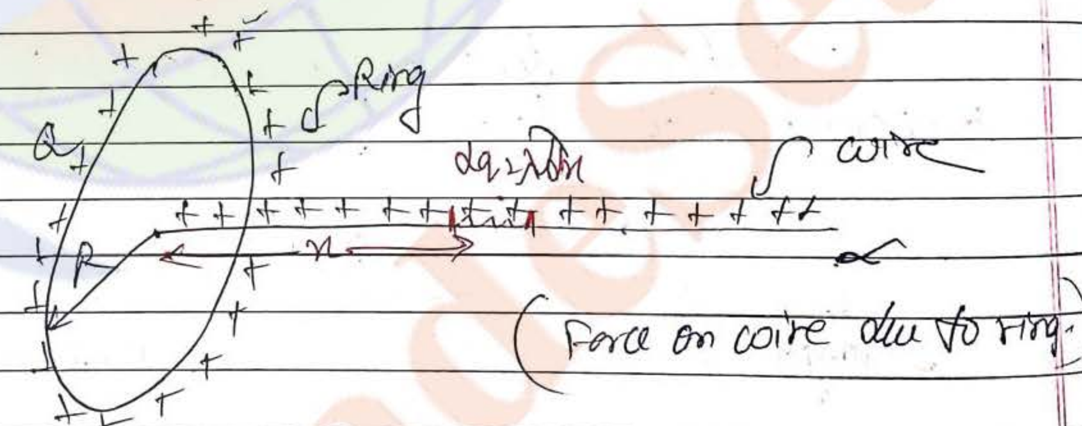
$$= \int_0^Q \frac{kx}{(x^2+R^2)^{3/2}}\, dq$$

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

Notes —



Dodde GA



Determine the force b/w wire and ring

Sol^n

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

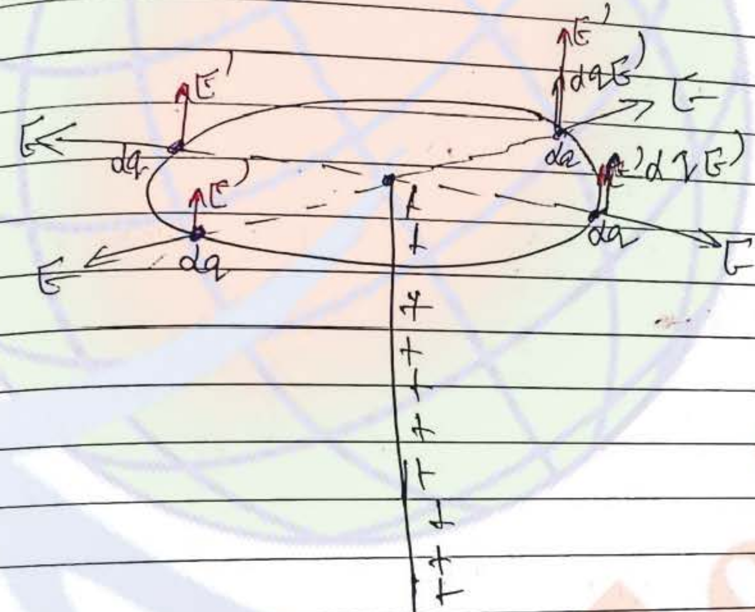
$$dF = dq\,E$$

$$dF = dqE$$

$$= \frac{\lambda K Q x \, dx}{(x^2+R^2)^{3/2}}$$

$$\int dF = \int_0^{\infty} \frac{K\lambda Q x \, dx}{(x^2+R^2)^{3/2}}$$

Alt



$F_{\text{on radial}} = 0$

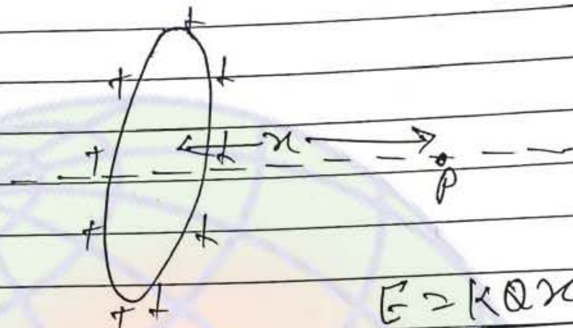
$F_{\text{parall to wire}} = dqE' + dqE' + dqE' + \dots$

$= E'[dq + dq + dq + dq + \dots]$

$= QE'$

$= \frac{Q\lambda}{4\pi\epsilon_0 R}$

★ E due to Ring Continue →



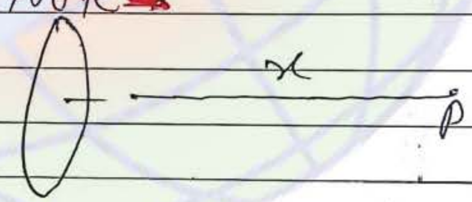
$$E = \frac{KQx}{(x^2+R^2)^{3/2}}$$

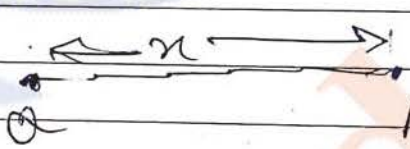
At $x = 0$, $E = 0$

At $x >>>>> R$

$$E = \frac{KQ}{x^2}$$ (neglect R^2)

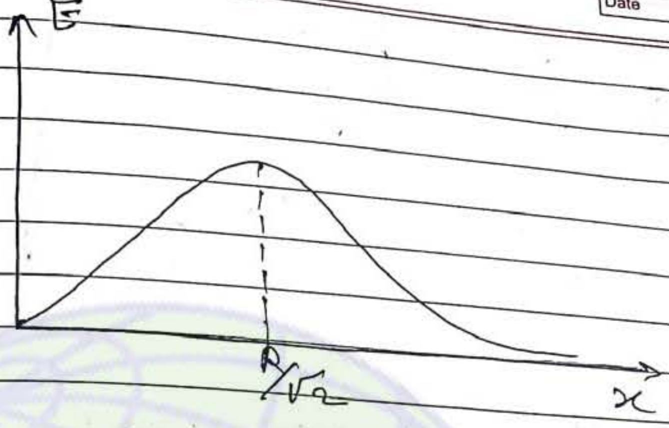
Note →





Behavior of Ring is like a point charge if point "P" is far away from the Ring.

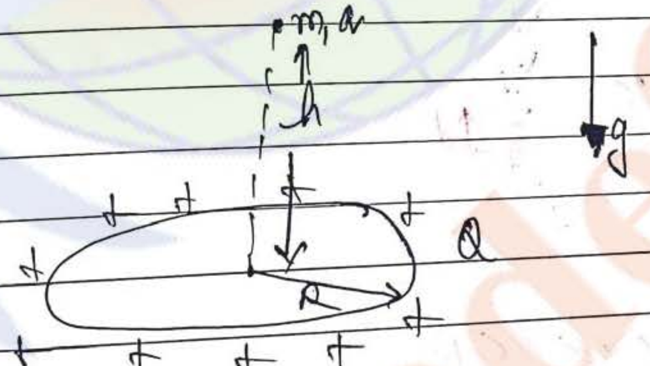
At ∞, $E = 0$



E is max. at $x = \frac{R}{\sqrt{2}}$ on both side of Ring.

$$\boxed{\begin{gathered} E = f(x) \\ \frac{dE}{dx} = 0 \\ x = \frac{R}{\sqrt{2}} \end{gathered}}$$

→ for maxima करना



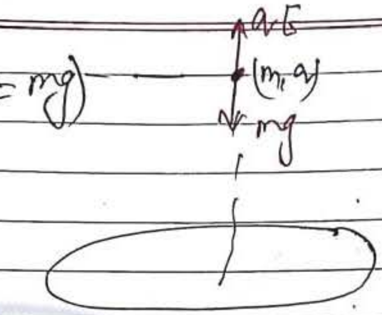
Q) For what value of h charge "q" will be in stable equillibrum along vertical direction.

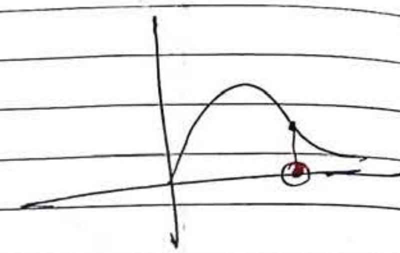
a) $h < \frac{R}{\sqrt{2}}$

b) $h > \frac{R}{\sqrt{2}}$

c) $h = \frac{R}{\sqrt{2}}$

Sol^n $(qE = mg)$





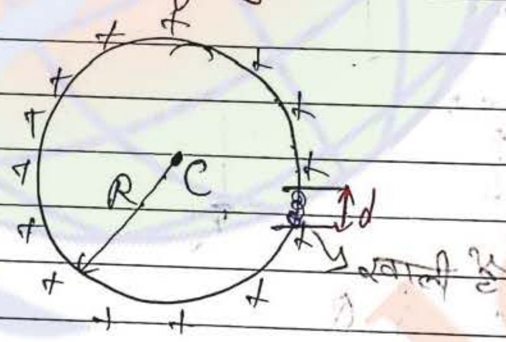
For stable eq^n we want:-
दूर जाने पर E घटे और Ring के पास आने पर "E" बढ़े।

So

$$h > \frac{R}{\sqrt{2}}$$

Question of कटा गायब and बचा हुआ Portion

Imp.

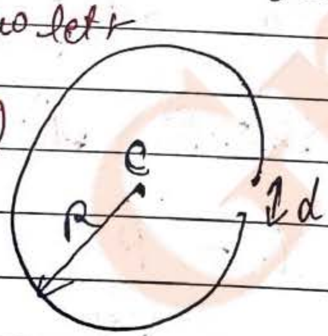


$$d <<<<< R$$

$$E \text{ at } C = ?$$

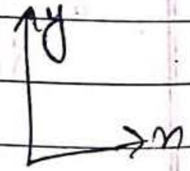
Sol^n Now let:-

(1)



" , " (2)

(गायब हुआ Portion)



~~Above (1) & (2)~~
Now

(1) + (2) $\Rightarrow$ Ring

$$\vec{E_1} + \vec{E_2} = \vec{E}_{\text{due to ring}}$$
$$= 0$$

charge on (2) $= \frac{Q \times d}{2\pi R}$

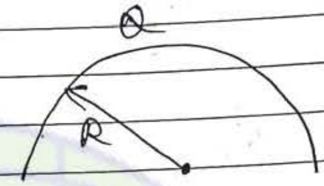
$$\vec{E_2} = \frac{k \times Q\, d}{2\pi R \times R^2}(-\hat{i})$$

$$\vec{E_1} = -\vec{E_2}$$

$$= \frac{kQ \times d}{2\pi R^3}\hat{i}$$

direction towards गायब हुआ portion

(Q.) Determine "E at C" due to half ring



E at c due to half Ring

Soln

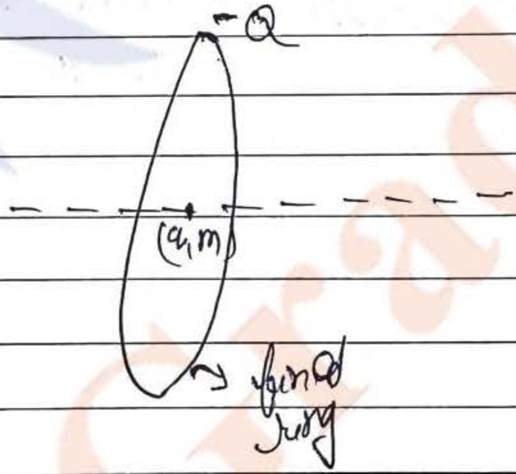
Half ring is basically an arc of π angle

$$E = \frac{\lambda \sin \pi/2}{2\pi \varepsilon_0 R}$$

$$= \frac{Q \sin \pi/2}{\pi R \, \pi \varepsilon_0 R} \qquad \left(\because \lambda = \frac{Q}{\pi R}\right)$$

$$\Rightarrow \frac{Q \sin \pi/2}{2\pi^2 \varepsilon_0 R^2}$$

(Q.)

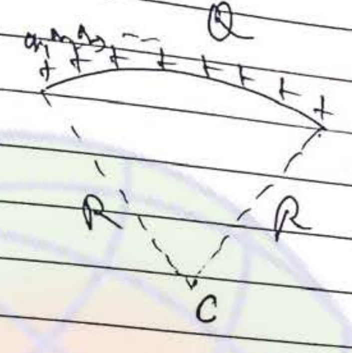


(g neglect)

examiner can ask question of SHM in case of ring of charge 'q' i.e. in stable eqn in centre of Ring.

V due to arc and Ring →

Arc →

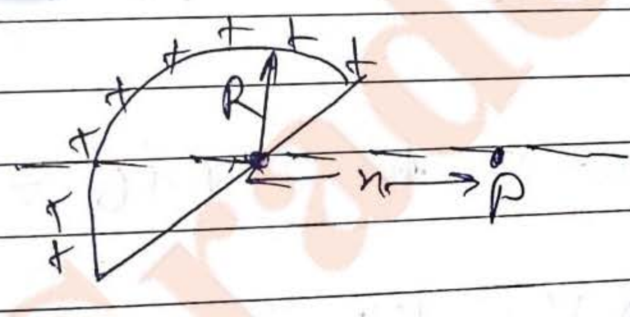


$$V_{centre} = \frac{k\,dq_1}{R} + \frac{k\,dq_2}{R} + \frac{k\,dq_3}{R} + \cdots$$

$$= \frac{k}{R}\left[dq_1 + dq_2 + \cdots\right)$$

$$\boxed{V_{centre} = \frac{kQ}{R}}$$

Note



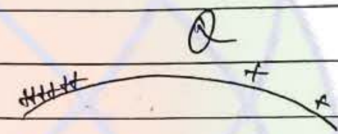
$$V_{\text{at the axis of Arc}} = \frac{kQ}{\sqrt{x^2+R^2}}$$

✲ Ring →

$$V_{centre} = \frac{KQ}{R}$$

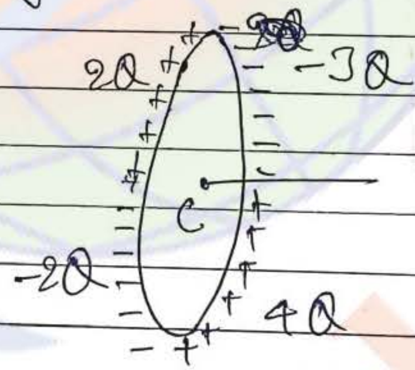
$$V_{axis} = \frac{KQ}{\sqrt{x^2+R^2}}$$

Note →



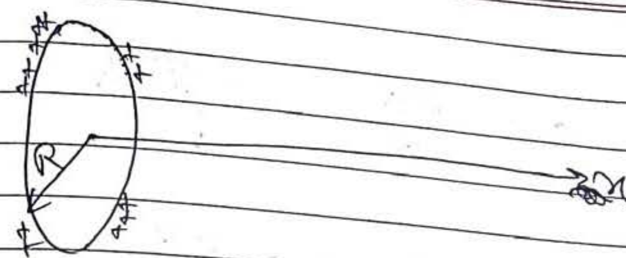
Formula of potential (V) for both arc and Ring is valid even if distribution of charge is non-Uniform

Non-Uniform distribution of charge



Total charge → $2Q - 2Q - 3Q + 4Q = Q$

$$V_C = \frac{KQ}{R}$$

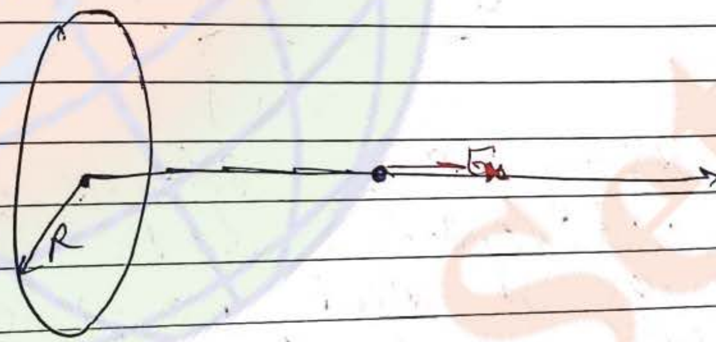


Non-uniform distributed ring here
Total charge "Q"

Determine

$$\int_0^\infty \vec{E} \cdot \vec{dx} = ?$$

, where
$\vec{E} \Rightarrow$ is electric field intensity due to ring on the axis.



$$\vec{E} = E_x \hat{i} + E_y \hat{j} + E_z \hat{k}$$

$$\vec{E} \cdot \vec{dx} = E_x \, dx$$

$$\int_0^\infty dV = -\int_0^\infty E_x \, dx$$

$$V_{at\ x=\infty} - V_{at\ x=0} = -\int_0^\infty E_x \, dx$$

$$0 - \frac{KQ}{R} = -\int_0^{\infty} E_x\, dx$$

$$\int_0^{\infty} \vec{E} \cdot dy = \int_0^{\infty} E_x\, dx = \frac{KQ}{R}$$

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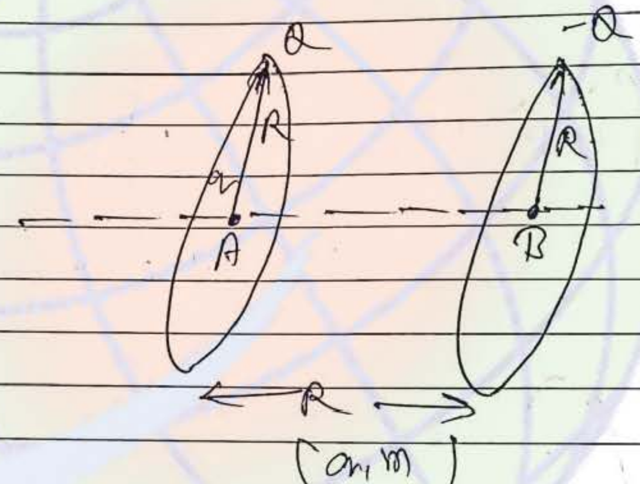
neglecting g



A charge Q is Released from point A at Rest Condition due to electric force of rings it start moving along the axis of both rings determine it's velocity when it Reach at point B.

sol^n

$q, m,$

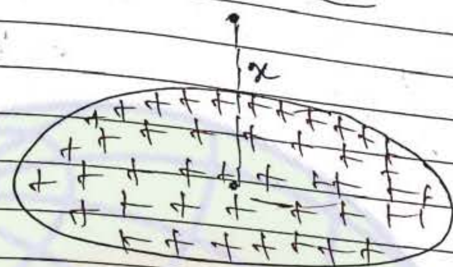
$$qV_A = \frac{1}{2}mv^2 + qV_B$$

$$q\left[\frac{KQ}{R} + \frac{K(-Q)}{\sqrt{2}R}\right] = \frac{1}{2}mv^2 + q\left[\frac{-KQ}{R} + \frac{KQ}{\sqrt{2}R}\right]$$

Q. I sir. →
Examiner can ask question of workdone as well as energy conservation in case of extended charge bodies also.

1st Choice ... $\vec{E}$ (derivation)

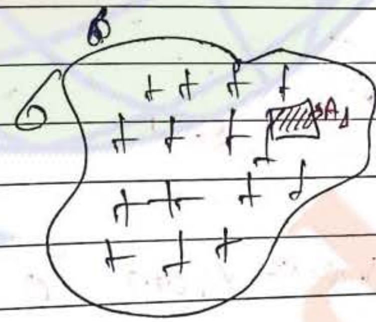
E and V due to disc →



charge is distributed on the surface not on the line.

Therefore this configuration is known as surface charge extended body.

$\sigma \Rightarrow$ charge per unit Area,
(Surface charge density)

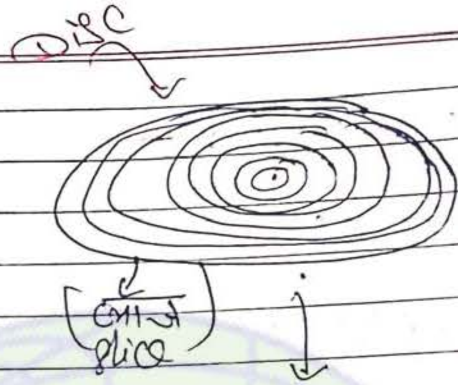


charge of $A_1 = \sigma A_1$

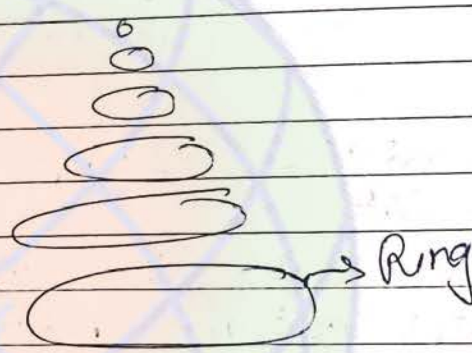
σ given,
$R \Rightarrow$ Radius of Disc,

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{x^2+R^2}}\right]}$$

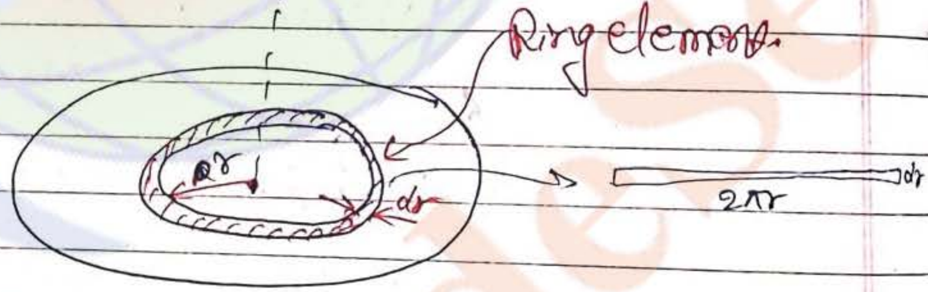
Direction along the x-axis.



Disc is like onion slide of salad



Disc ~~Ring~~ can be considered as consist of ring.



∴ "r" varies from "0" to "R".

Area of element $= dA = 2\pi r\,dr$

charge on element $= dq = \sigma\,dA = \sigma \times 2\pi r\,dr$

$$dE = \frac{k\,dq\,x}{(x^2+r^2)^{3/2}}$$

$$dE = \frac{xK + \sigma \times 2\pi r dr}{(x^2+r^2)^{3/2}}$$

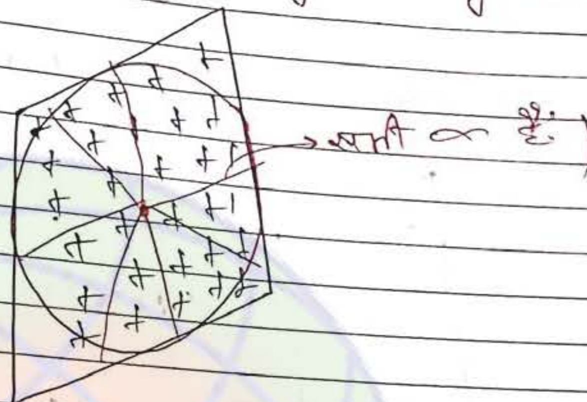
$$E = \int_{r=0}^{r=R} dE$$

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{x^2+R^2}}\right]}$$

1st Choice

ask 3 times question

E due to Infinitely large charge sheet →



Infinitely large charge sheet can be consider as it is a disk of Infinite radius.

Put ~~R = ∞ , In the given eq^n~~

$$E = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{x^2+R^2}}\right]$$

(without sign)

Put $R = \infty$

$$E = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{x}{\infty}\right)$$

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

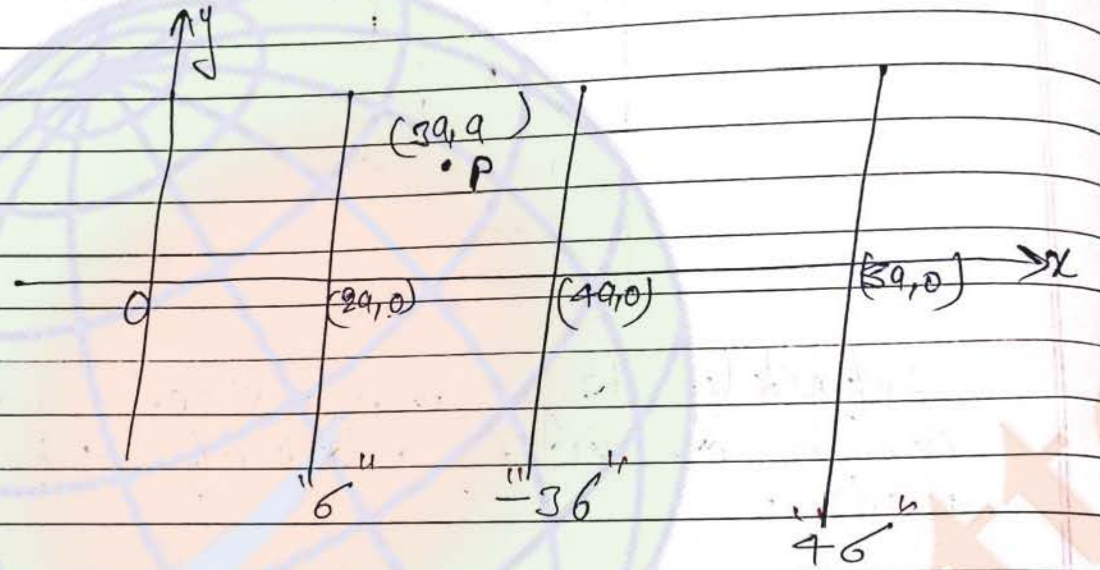
take "σ" without sign.

Note

1) E due to Infinitely large charge sheet is Uniform Electric field

11) Direction of E is normal to sheet

11T Q91.)



Determine "E" at P.

$$\longrightarrow \frac{3\sigma}{2\varepsilon_0}$$

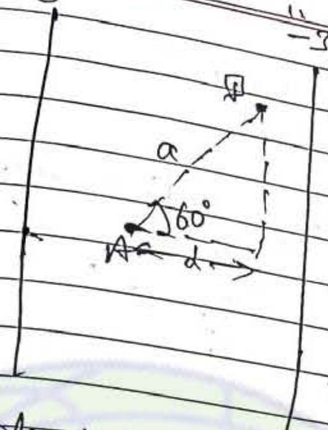
$$\frac{4\sigma}{2\varepsilon_0} \longleftarrow P \longrightarrow \frac{\sigma}{2\varepsilon_0}$$

$$\frac{4\sigma}{2\varepsilon_0} - \left(\frac{3\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}\right)$$

$$\Rightarrow \frac{4\sigma}{2\varepsilon_0} - \frac{4\sigma}{2\varepsilon_0}$$

$$\Rightarrow \text{"}0\text{"}$$

93) -36



Determine $V_B - V_A$

Sol[n] Concept →
~~In case of sheet "E" is uniform~~
In case of sheet "E" is uniform
Therefore to determine Potential difference b/w any two point's used formula

$$V_A - V_B = -\vec{E}\cdot\vec{BA}$$

$$\Delta V = EA$$

and to use this formula for first we determine E.

(A और B के इलाके में "E" निकालना होता है) |

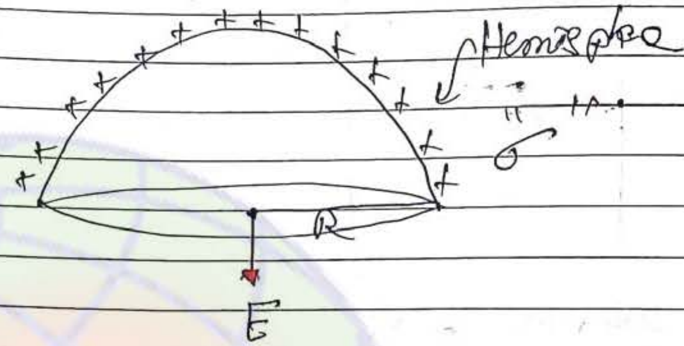
$\longrightarrow \frac{36}{2\varepsilon_0}$

$\longrightarrow \frac{6}{2\varepsilon_0}$

$$E = \frac{46}{2\varepsilon_0} = \frac{26}{\varepsilon_0}$$

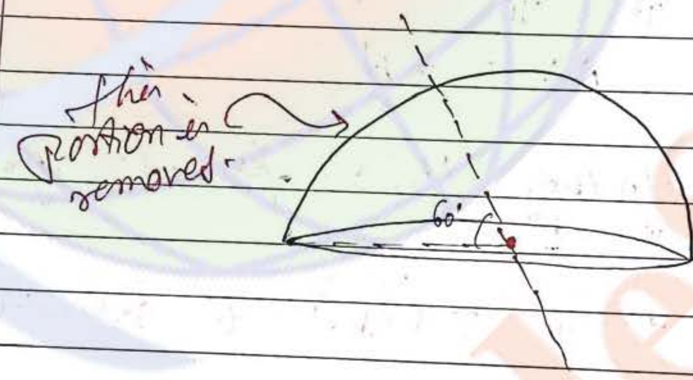
very good

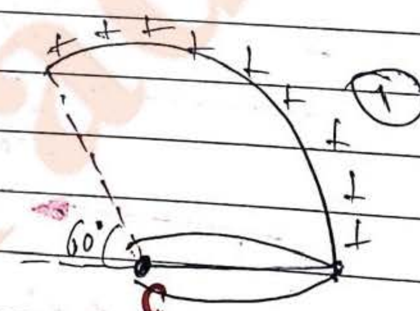
$V_B - V_A = -E \times a\cos 60^\circ$



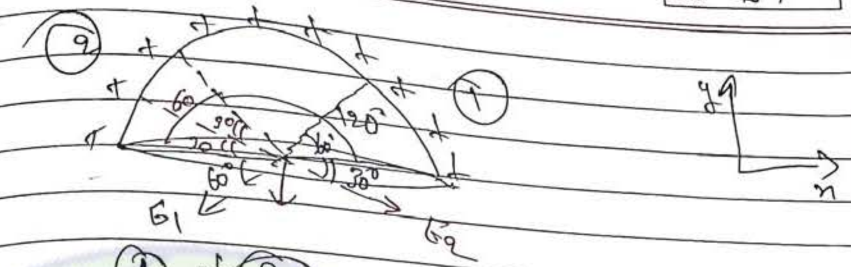
$$\boxed{E_{at\,C} = \frac{\sigma}{4\varepsilon_0}}$$

Now we cut it as





Determine E at centre due to remaining portion



(1) + (2) ⇒ अर्धगोला (Hemisphere)

At "i"

$$\vec{E}_1 + \vec{E}_2 = \vec{E} \text{ due to Hemisphere}$$

$$= \frac{6}{4\varepsilon_0}(-\hat{j})$$

Always form by vector method the type of question.

$$-E_1 \cos 60^\circ \hat{i} - E_1 \sin 60^\circ \hat{j} + [E_2 \cos 30^\circ \hat{i} - E_2 \sin 30^\circ \hat{j}] = \frac{6}{4\varepsilon_0}(-\hat{j})$$

$$\frac{\sqrt{3}\, E_2}{2} - \frac{E_1}{2} = 0$$

$$E_1 = \sqrt{3}\, E_2$$

Sol^n for E_2

$$\frac{-\sqrt{3}}{2} E_1 - \frac{E_2}{2} = \frac{-6}{4\varepsilon_0}$$

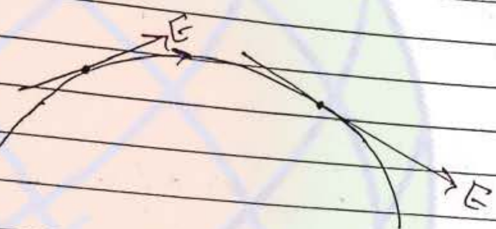
1st Choice

Electric flux and Gauss law

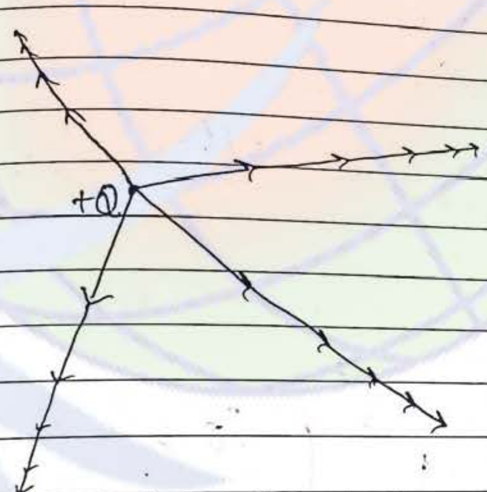
Page No. 225
Date / /

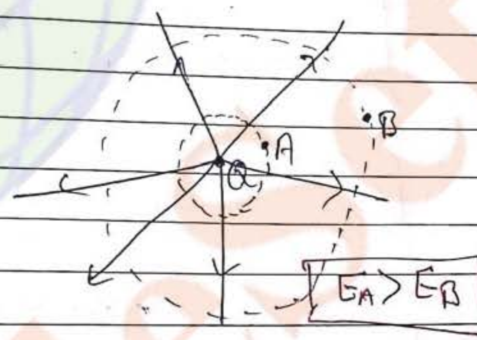
Electric lines of force (ELF) ⇒ 1) ELF are hypothetical curves or lines drawn on paper to represent electric field on paper

2) ELF are drawn on paper (or board or table) in such a way that tangent at any point on the line give direction of "$\vec{E}$" ~~at any~~ at that point



3)



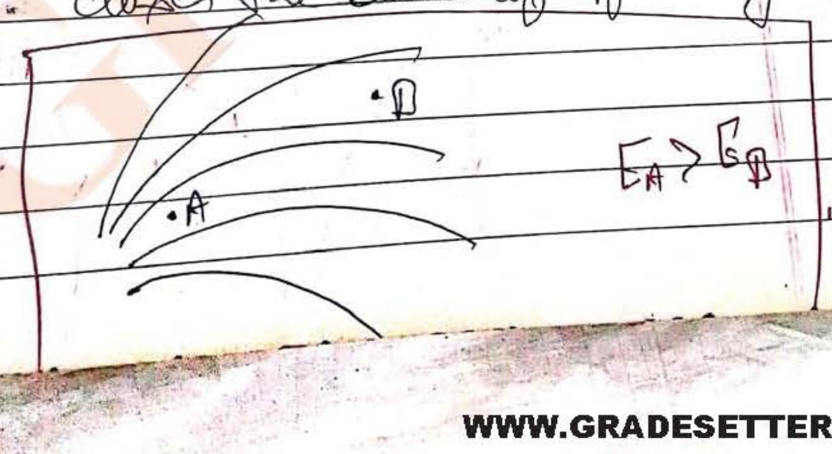


- magnitude of electric field intensity is proportional to relative density of electric lines of force (No. of electric lines of force passing through unit area)

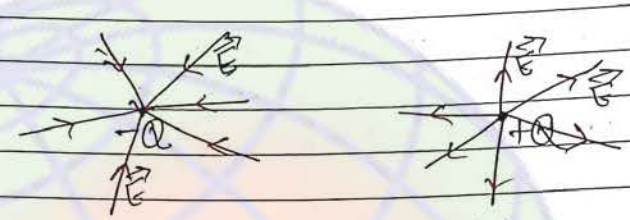
closer the lines of force higher the "E"

~~the~~

g1→

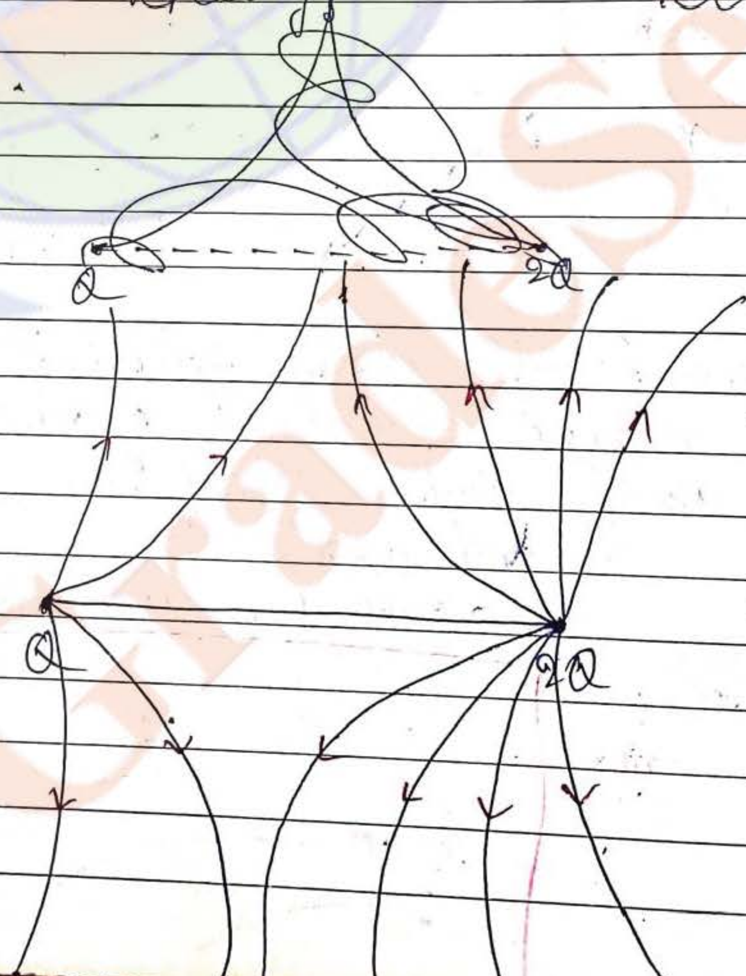


4) ELF begin from "+ve" charge ~~to~~ and end at "-ve" charge.



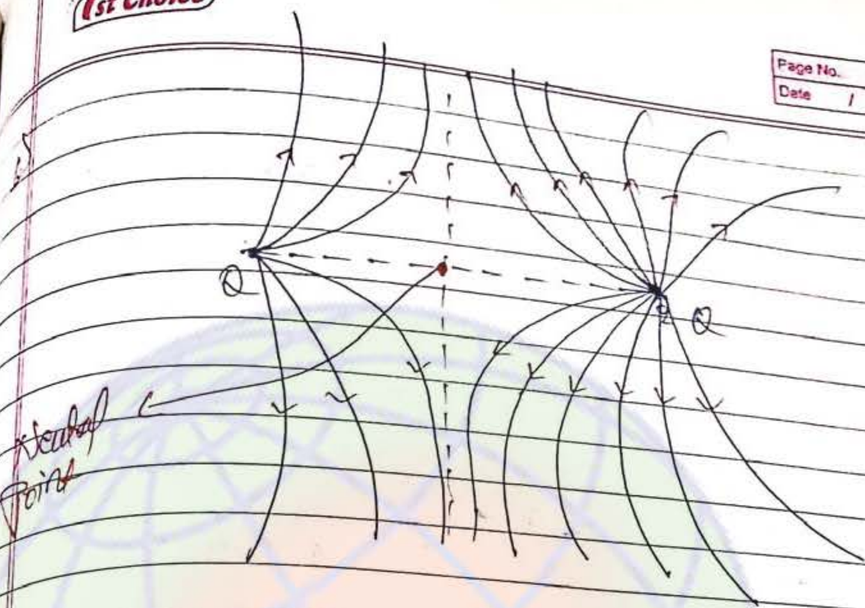
No. of lines from any charge $\propto$ magnitude of charge

Lines are repelling each other (छीसा भगाता है)

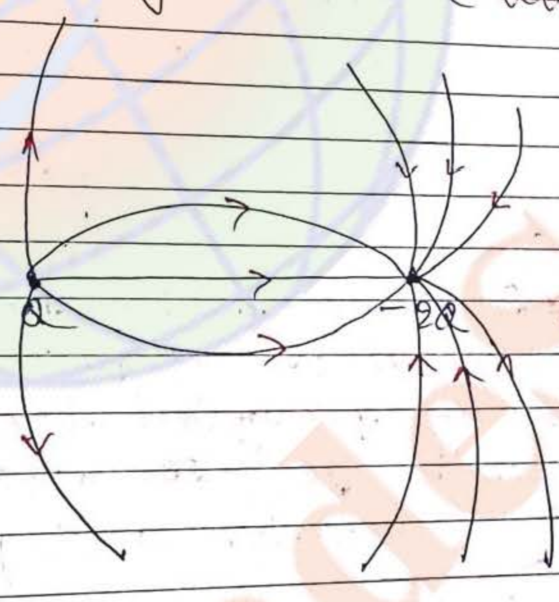


$\frac{Q}{2Q} = \frac{4}{8}$

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

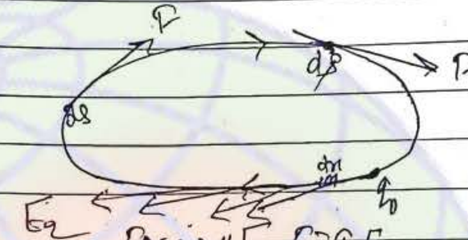


7) Lines are attracting each other (ऐसा लगता है)



8.) Two ELF never Intersect each other because an Intersection point there will be two direction of E at same point which is Impossible.

9) ELF never form a closed loop because Electric field is a conservative field



Assume this ELF

$P\,ds \cos\theta$ = +ve
$P\,ds \cos\theta$ = +ve
+ve
+ve

Here W = +ve. but W in closed path is zero. Hence our assumption is wrong.

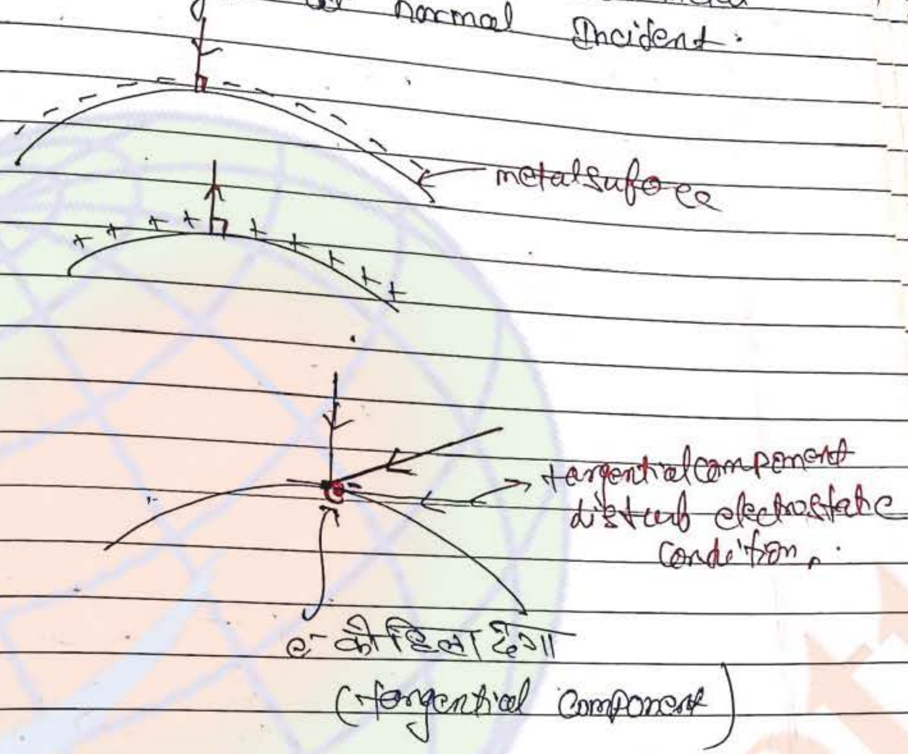
(यहाँ सभी workdone +ve ही हो रहे हैं और इनका sum भी इस प्रकार +ve ही होगा। जबकि workdone by conservative force in closed loop is zero होना चाहिए इसलिए यह possible नहीं है कि electric field lines closed loop बनाएँ)

10) In electrostatic condition ELF does not present inside conductor because Electric field is zero in electrostatic conductor.

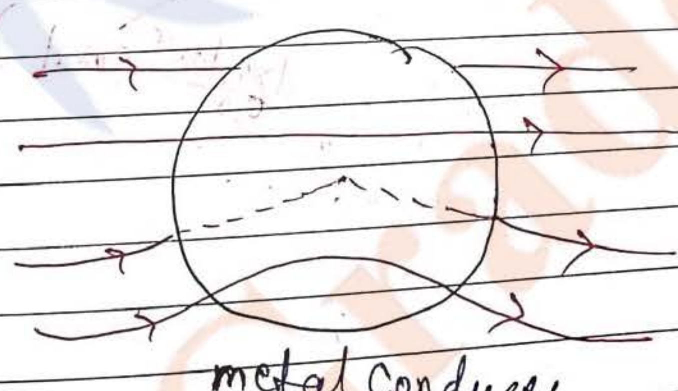
कोई shape conductor

Conductor

(i) On electrostatic condition ELF on metal surface are always at normal incident.

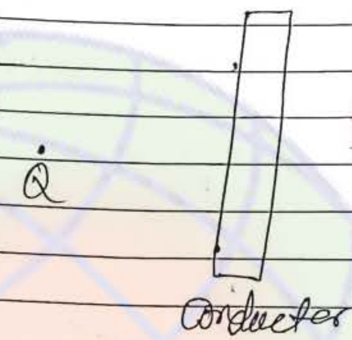


(40) Which ELF is सबसे True.

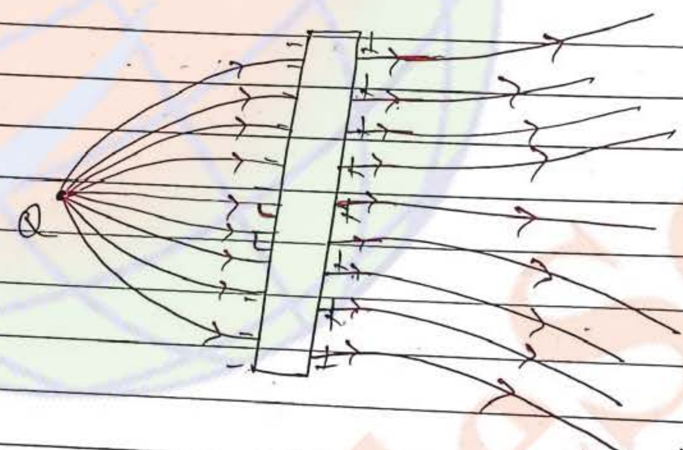


Ans 3

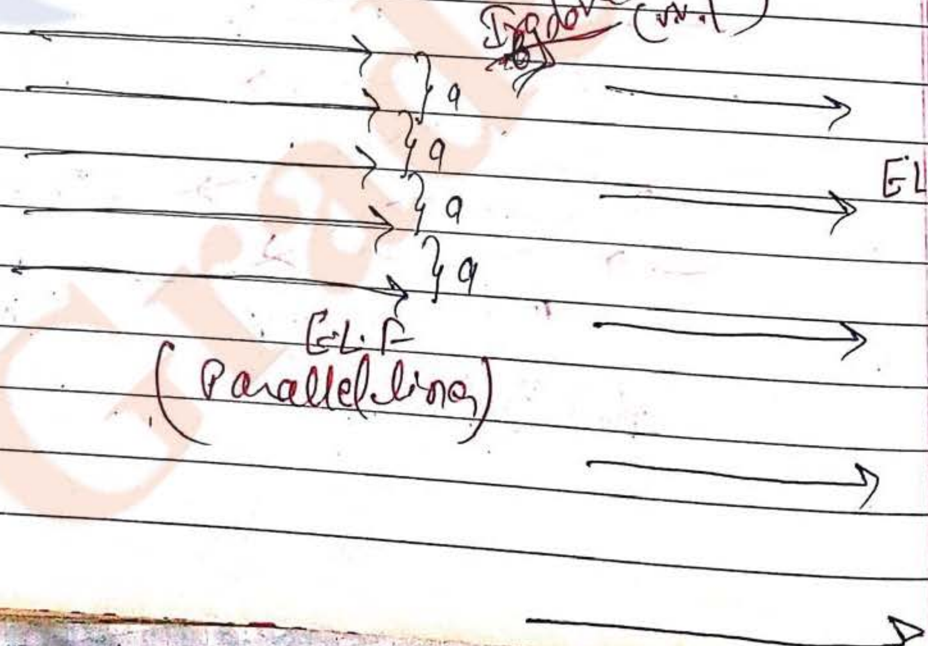
Ex 2) Draw E.L.F for the following case!



Sol^n



Ex 9) a) Ignore (v.1)



1st Choice

ELF
Go 2 1 → 24, Go 2 4 → 9, and 17, Go 2 2 → 99

clear 29

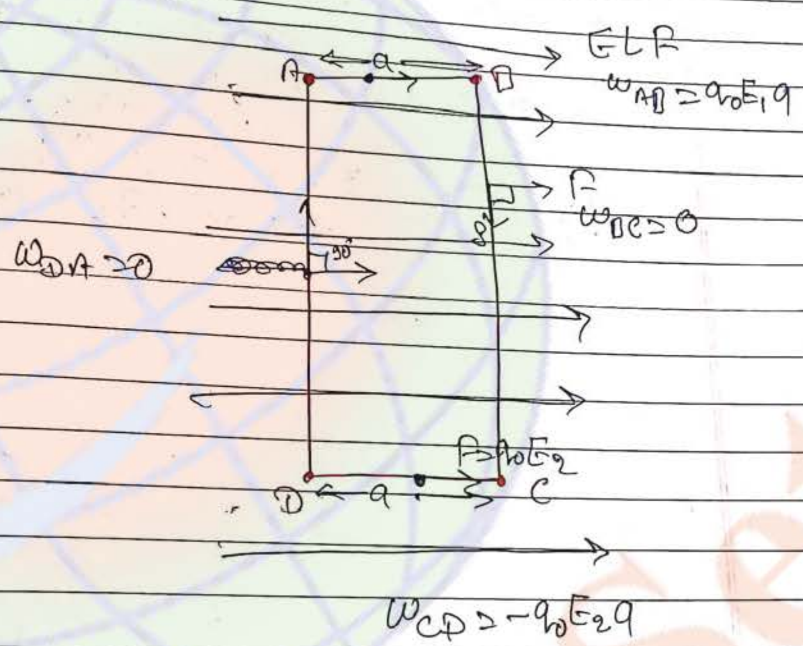
Go 27 (all passage 17, 9, 11, 6, 7, 15,

Page No.
Date 17, A),

A) Uniform E (direction, gape same है, magnitude same है)

B) Non-Uniform ELF diagram है।

This E does not represent any type of "E"



$W_{total} = q_0 E_1 a - q_0 E_2 a$

$\because E_1 > E_2$

$W_{net} \neq 0$ (here)

work done by conservative force in closed loop is zero होता है।
but here work done by closed loop is not zero so, we say that this field lines are not possible

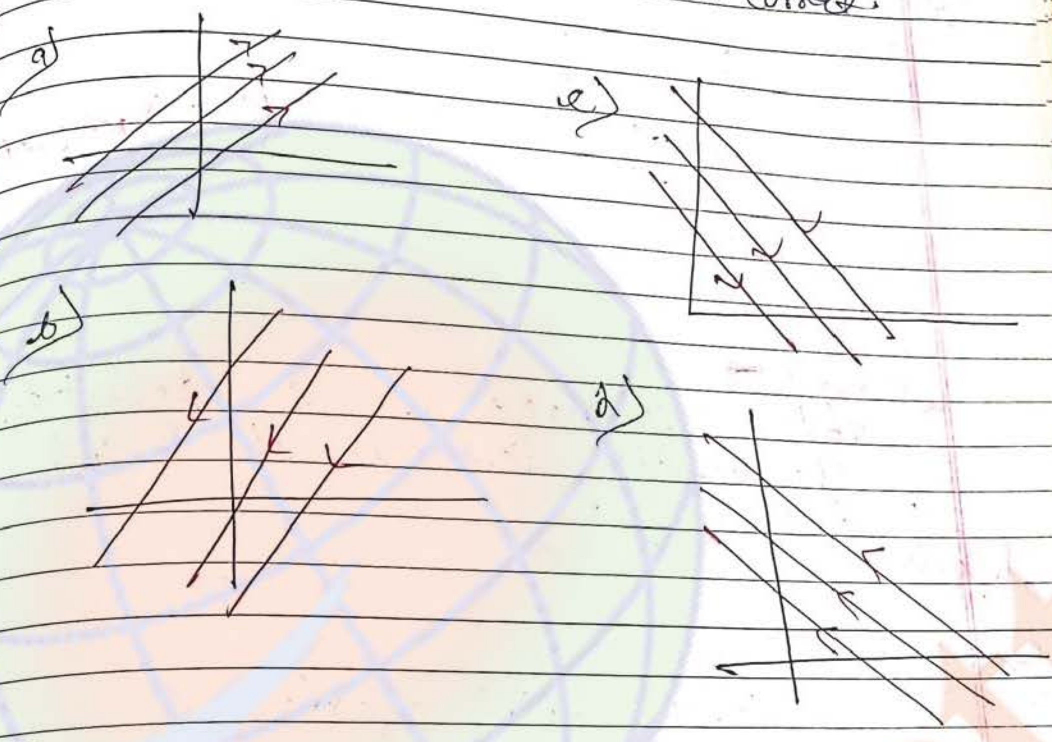
Attention + Attention + Attention + Attention + Attention →

Electric lines of force (अर्थात $\vec{E}$) +ve charge से निकलता है और -ve charge में प्रवेश करता है।

अर्थात +ve से निकलकर -ve में प्रवेश करता है।

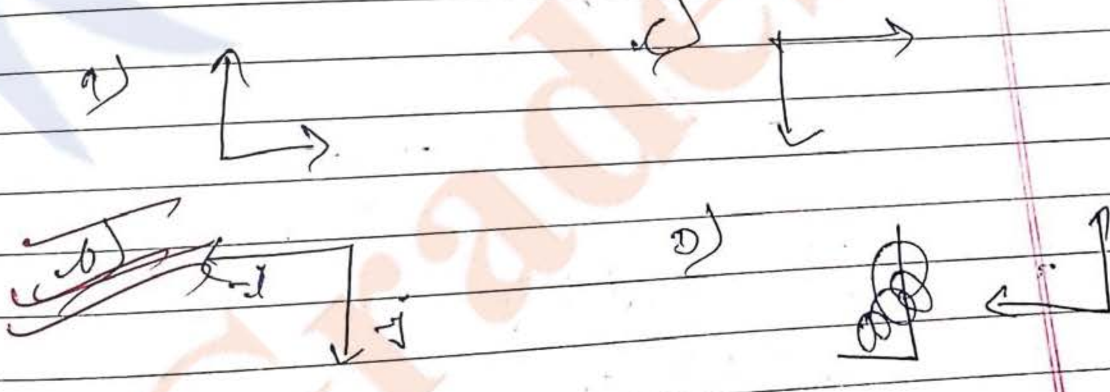
जबकि dipole moment ($\vec{P}$) का direction इसके "उल्टा" है। dipole moment ($\vec{P}$) -ve से +ve की ओर जाता है।

Q. $V = x + y$ which E.L.F is correct.



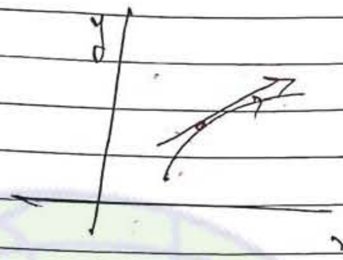
Sol. $\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j}$

$\vec{E} = -\hat{i} - \hat{j}$ (यहाँ $-\hat{i}$, और $-\hat{j}$ [illegible])



92) $V = x^2 - y^2$

$E = -2x\hat{i} + 2y\hat{j}$



$x = +ve,\ y = +ve$

(X) not correct

G.B. Soln →

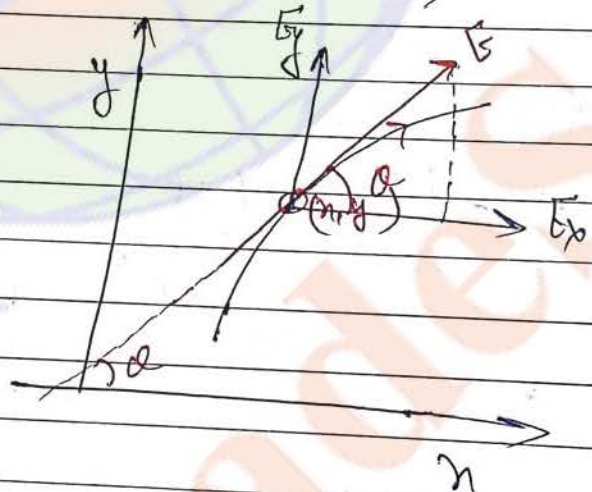
- After determination of E check out the direction components of "E" with the E.L.F.

High level

eg. 1) $V = x^2 - y^2$

Determine E.L.F equation.

Soln



$\tan\theta = \frac{E_y}{E_x}$

$\vec{E} = -2x\hat{i} + 2y\hat{j}$

$\ln xy = c$

~~$xy =$ constant~~

$$\frac{dy}{dx} = \frac{E_y}{E_x}$$

$$\frac{dy}{dx} = \frac{2y}{2x}$$ $\int$ E_y, E_x sign के समान

$$\int \frac{dy}{y} = \int \frac{dx}{-x}$$

$$\boxed{\ln y = -\ln x + C}$$

$$\ln y + \ln x = C$$

$$\ln xy = C$$

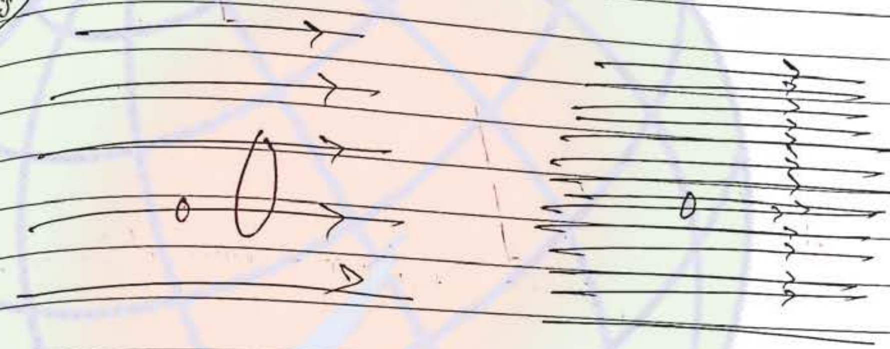
$$xy = C$$

Electric flux (ϕ) → (flux is a scalar quantity)

1) Electric flux through a surface is a quantity which is proportional to number of E.L.F passing through that surface. (No. of electric field lines passing through an area in the direction of area vector is known as electric flux.)

2) Higher the flux mean's higher the number of E.L.F passing through the surface

3)



Flux depend on I) magnitude of $\vec{E}$ (Electric field intensity), II) Area of the surface, III) orientation of surface

Determination of Flux in uniform $\vec{E}$ →

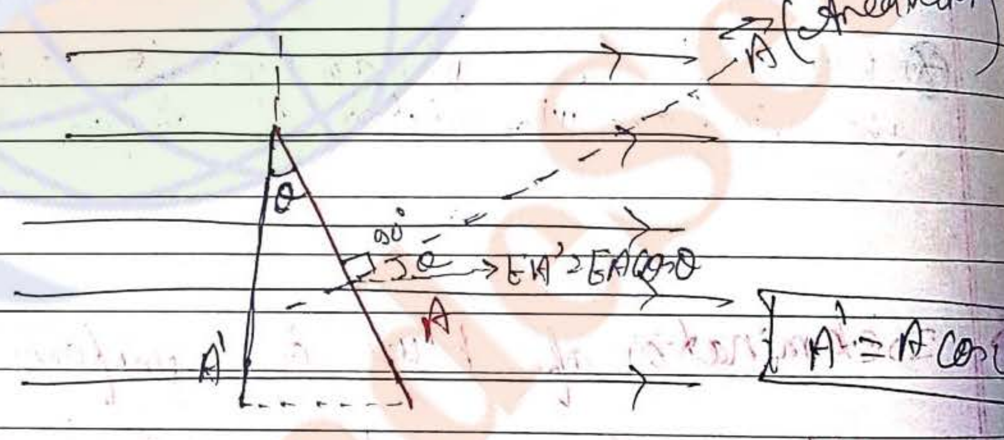
Case 1st → Surface is Plane Surface →

$$\boxed{\text{Number of lines passing through unit area} \propto E}$$

$$\boxed{\text{No. of lines passing through unit area} \propto E_A} \rightarrow \phi$$

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

where surface is normal to "E".



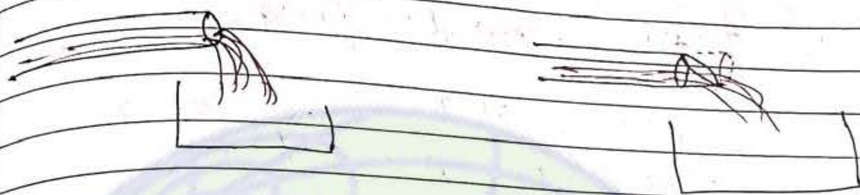
$$\boxed{A' = A\cos\theta}$$

$$\boxed{\begin{aligned}\phi \text{ through } A &= \phi \text{ through } A' \\ &= EA' = EA\cos\theta\end{aligned}}$$

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

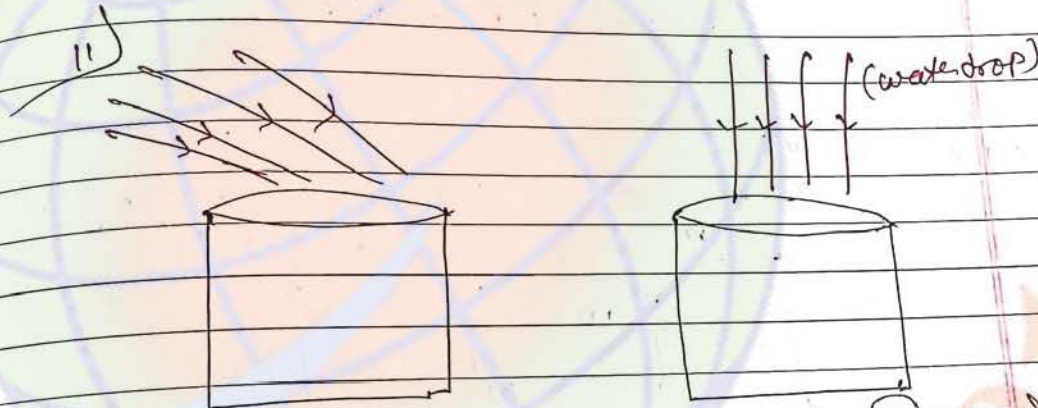
1st Choice

Note→ 1) flux समझते



दोनों case में ~~case~~ same पानी गिरेगा so,
दोनों case में same flux.

11)

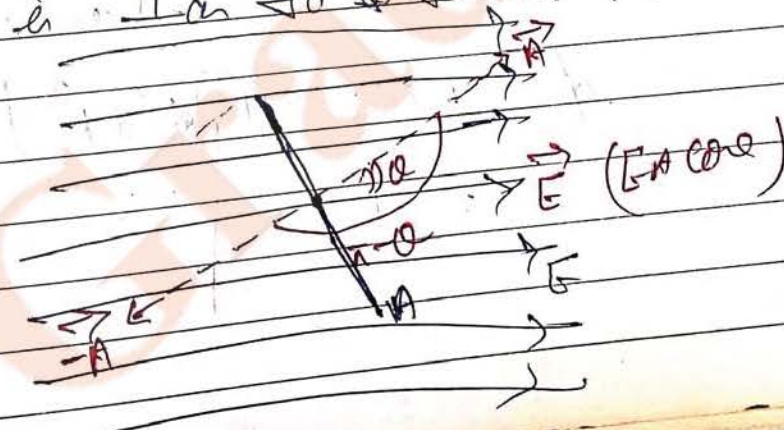


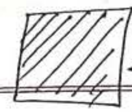
(पानी ज्यादे ~~ज~~ जाएगा)

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

where

$\vec{A} \Rightarrow$ Area vector is the vector whose magnitude is Area of surface and whose direction is $\perp$ar to ~~the~~ the surface





gauss law defined flux

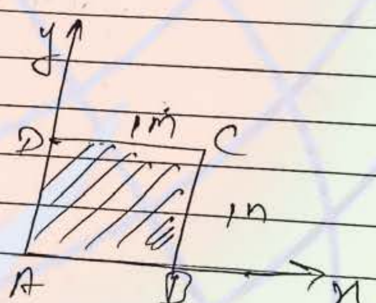
Here

1) ϕ = +ve ~~(stands for)~~

means E.L.P are going on the side where $\vec{A}$ is taken

2) ϕ = -ve

means E.L.P are going on the opposite side of $\vec{A}$.



$\vec{E} = 2\hat{i}+3\hat{j}+4\hat{k}$

ϕ through ABCD = ?

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

$\vec{A} = 1\hat{k}$ (Area vector surface के ⊥ होता है)

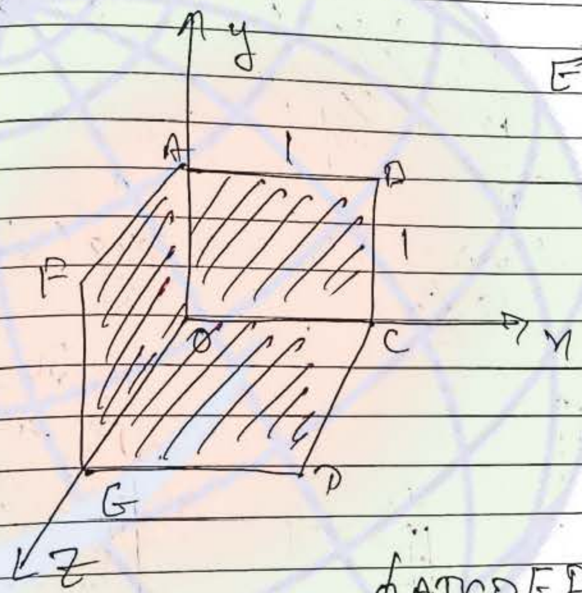
$\phi = (2\hat{i}+3\hat{j}+4\hat{k})\cdot(1\hat{k})$

$= 4$

$\hat{k}\cdot\hat{i} = 0$
$\hat{k}\cdot\hat{j} = 0$
$\hat{k}\cdot\hat{k} = 1$

Advice -

Some time surface consist of more than one surface then we should determine flux through each surface individually and then add them together.



$E = 2\hat{i} + 3\hat{j} + 4\hat{k}$

$\phi_{ABCDEF} = ?$

$\phi_1 = (2\hat{i} + 3\hat{j} + 4\hat{k}) \cdot (\hat{k}) = 4$

$\phi_2 = (2\hat{i} + 3\hat{j} + 4\hat{k})(1\hat{i}) = 2$

$\phi_3 = (2\hat{i} + 3\hat{j} + 4\hat{k})(1\hat{j}) = 3$

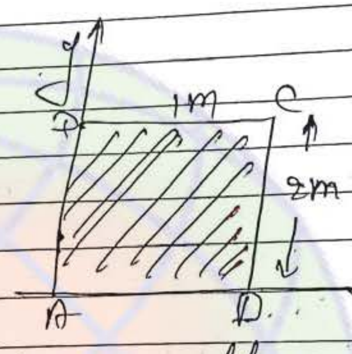
So,

$\phi = \phi_1 + \phi_2 + \phi_3$

$\phi_{net} = 9$

(18) Question in which E is non-uniform but surface is plane

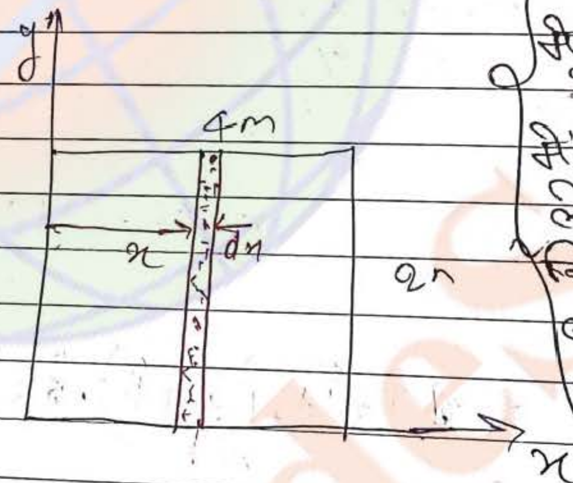
Ex.



$E = 2x\hat{k}$

Determine flux through the given surface.

Sol.



नोट ⇒ $\vec{E}$, x-direction में change कर रहा है इसलिए x-direction में ही element dx लेना चाहिए जिससे कि उस छोटे से element "dx" पर "E" same ही रहे

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

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

Area of Rectangle = $(2 \cdot dx)$

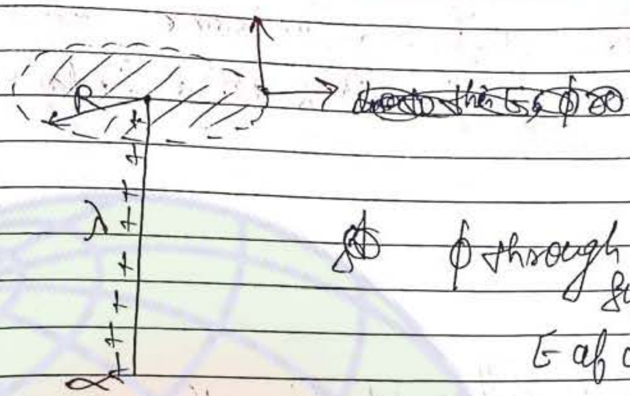
$= 2x\hat{k} \cdot (2dx)\hat{k}$

ही ऐसा Area vector लेना है जिसके सभी Points पर E same हो।

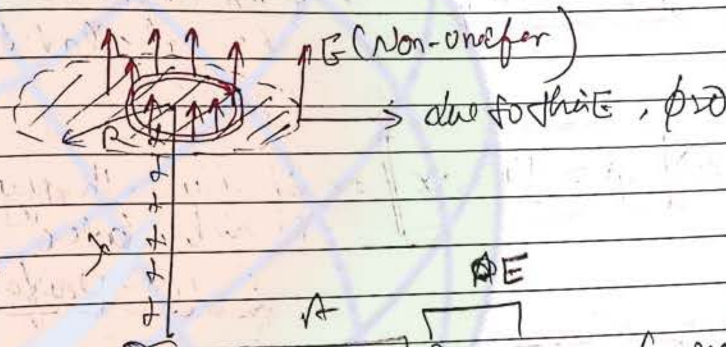
$d\phi = 4x\,dx$

$\phi = \int_0^4 4x\,dx$

(4)



φ through circular surface due to E of wire = ?



$$d\phi = \underbrace{2\pi r\,dr}_{A} \times \overbrace{\frac{\lambda}{4\pi\varepsilon_0 r}}^{E}$$ (see C.N → P-178)

$$\int d\phi = \int_0^R \frac{\lambda}{2\varepsilon_0}\,dr$$

$$\phi = \frac{\lambda \times R}{2\varepsilon_0}$$

Note →
Non-Uniform "E" में element लेना होगा for that "E" is uniform over that element and for this "I" have to use my brain

कि कहाँ तक (कैसे) element लेकि
E unifor है d वाकिट. Integ कर दें

Notes –

1) $\boxed{\phi = E \cdot A}$ ⇒ If flux through an area is to be calculated and EF is constant.

2) $\boxed{\phi = \int E \cdot ds}$ ⇒ If flux through an area is to calculated and EF is non-uniform

3) $\boxed{\phi = \oint E \cdot ds}$ ⇒ If flux through closed area is to be calculated.

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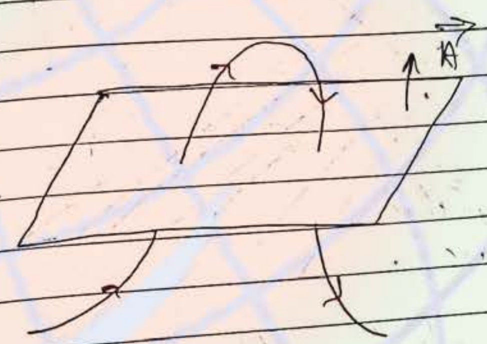
Date 1-1

Concept of Equivalent plane

Dialogue ⇒
when an E.L.F passes through the surface two times or even number of times then flux due to that E.L.F through the surface is "zero".

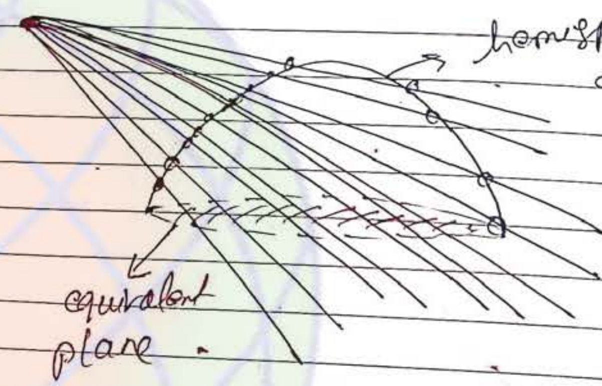


(flux is zero)

Notes ⇒ Here
यहाँ जो Red Pen से E.L.F दिखाए वह Surface से Pass [illegible]

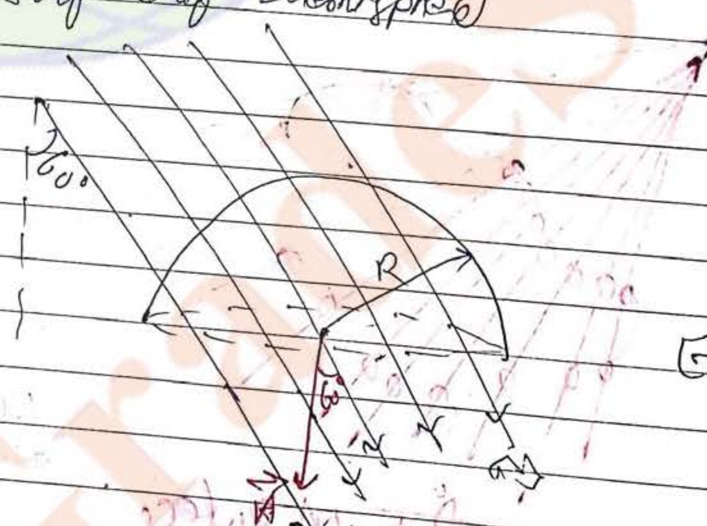
$\phi_{\text{अतिरिक्त surface}} = \phi_{\text{through equivalent plane}}$

Ex.



(P) value of electric flux is Independent of shape and size of surface.

Ex.) Determine flux through the curved surface of hemisphere

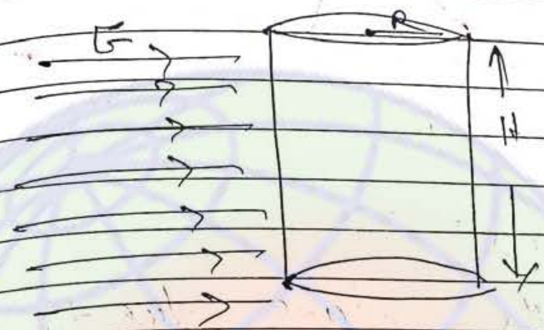


$\phi = EA\cos\theta$

$= \frac{E \times \pi R^2}{2}$

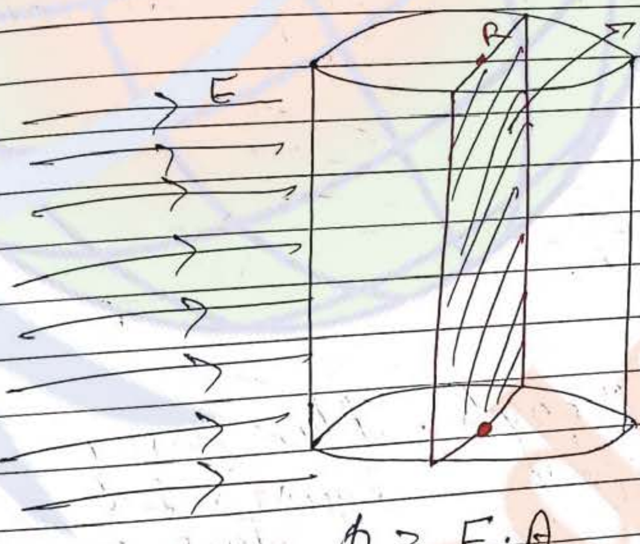
Q) Determine flux "entering in the cylinder"

सब surface से सिर्फ enter कितना कर रहा है उसका flux मांग रहा है।



नोट – मतलब बोलता कि E.L. R कौन इस इस cylinder के दोनों surface को पार करने पर Electric flux क्या होगा तब तो zero होता (क्योंकि two any surface से pass होती

equivalent plane.



∴ Area of Rectangle है $2R \times H$

$$\phi = E \cdot A$$

$$\phi = E \times 2R \times H$$

(सिर्फ Enter कितना किया)

Concept to solving this type of question → से अंदर जाने पर A/q हमें E की सिर्फ curve surface का flux माँग रहे हैं लेकिन उस curve surface का Area निकालना भी है लिए कठिन पड़ता है।

लेकिन एक बात यह भी है कि हम इस curve surface का Area न निकालकर उसके center पर बनने वाले equivalent plane का Area निकाल दें जो कि आसान है उससे भी flux दोनों case में flux same होगा तो यहीं हम equivalent plane से "φ" find करें।

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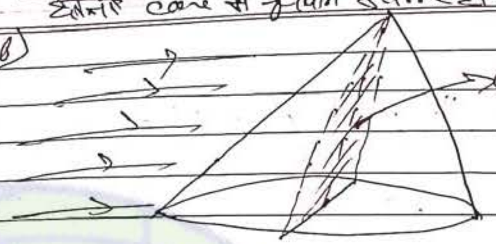
1st Choice

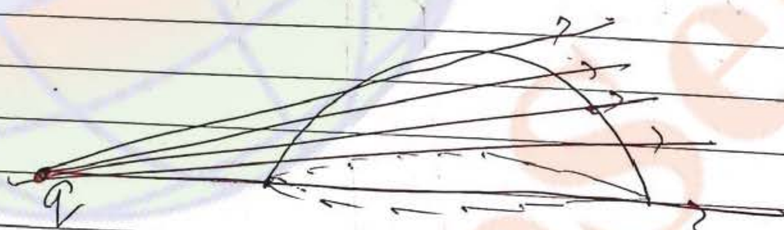
b)



Concept (GD sir) →

★ flux through the plane due to a charge is zero if charge is present in that plane.

Q) Determine flux through Hemisphere.



flux through hemisphere = flux through equivalent plane and charge q in equivalent plane

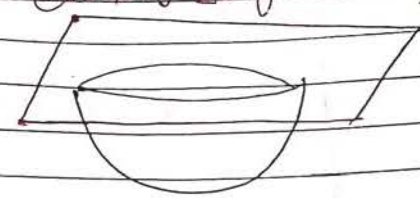
Therefore flux through hemisphere is zero

⇒ flux of a constant vector through any closed surface is zero.

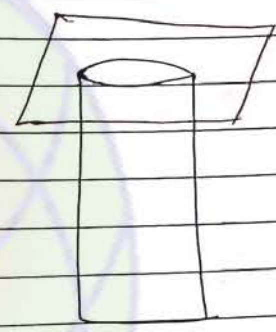
Concept of closed surface and open surface →

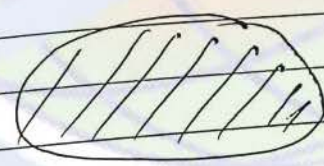
Open surface | closed surface

कटोरा

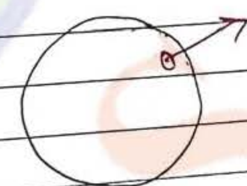


गिलास

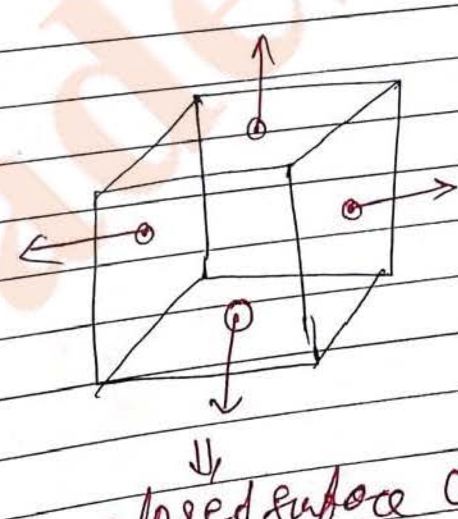




DISC



sphere,



⇓

(1) closed surface consist of one or more than one surface

which enclose certain Inside them (मैं अपनी दुनिया बनाता हूँ)

ii) In closed surface area vector is taken "outside" of enclosed volume

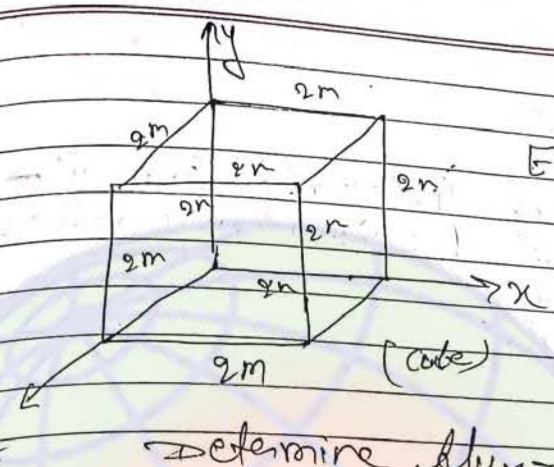
iii) $\phi = +ve \Rightarrow \phi$ outward

$\phi = -ve \Rightarrow \phi$ Inward

Total $\phi = \phi_{in} + \phi_{out}$

ϕ_{in} को -ve में लिखेंगे,

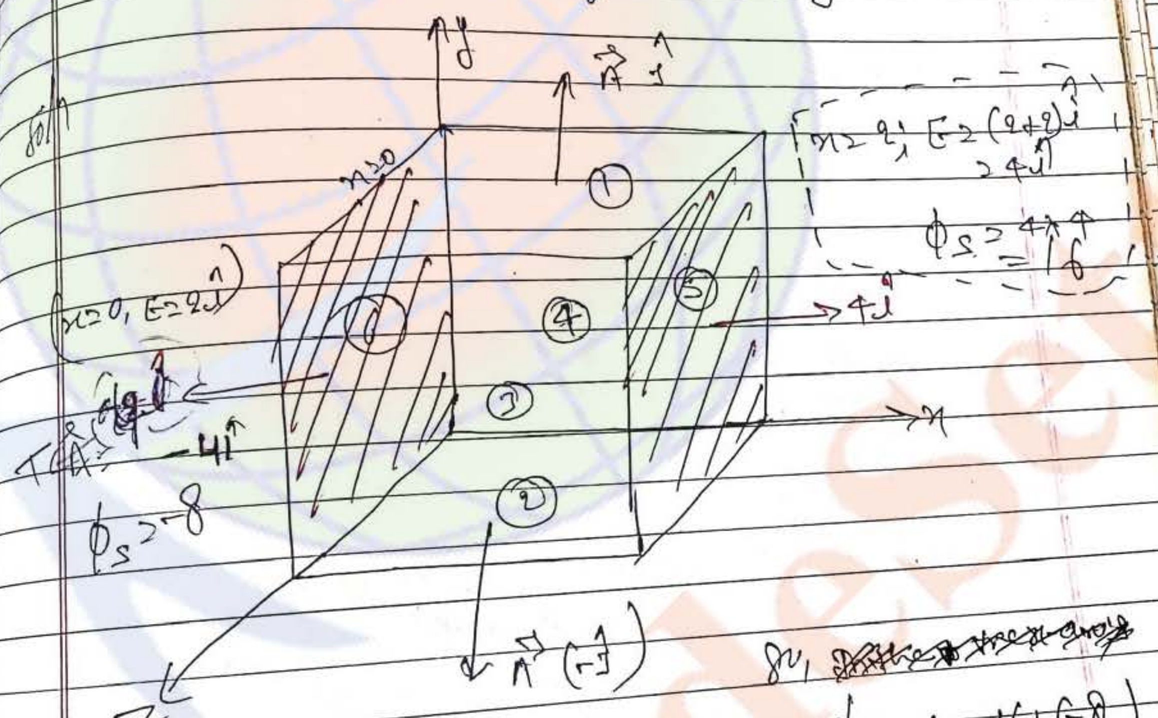
ϕ_{out} को +ve में लिखेंगे



$E = (2-x)\,\hat{i}$

Determine flux through the cube.

Soln



So, ~~...~~

$\phi_{total} = 16 + (-8)$
$= 8$

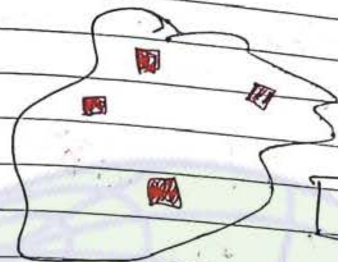
$\phi_1 = 0$
$\phi_2 = 0$
$\phi_3 = 0$
$\phi_4 = 0$

$\vec{E} \perp \vec{A}$

$\phi_5 = 16$
$\phi_6 = -8$

~~Flux three~~
Three type of Integration होता है:→
i) line Integral (इसलोग सीधा लिख नहीं बढ़ते है)
ii) Surface Integral
iii) volume Integral

Flux through अनियमित closed surface



3-D shape

1) we will take very small area element on अनियमित की surface because this element can be consider as plane surface.

2) Our element is so small, that even in non-uniform "E" can be assume uniform over that small area, and therefore we can determine flux through area element by the formula.

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

$$\boxed{\phi_{\text{closed surface}} = \oint_S \vec{E}\cdot d\vec{A}} = \vec{E}\cdot d\vec{A} + \vec{E}\cdot d\vec{A} + \dots$$

ये surface Integral है।

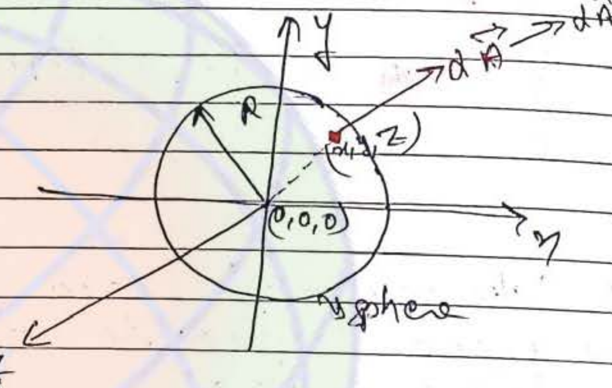
1st Choice

Page No. Date

Example

$\vec{E} = \dfrac{a(x\hat{i} + y\hat{j})}{x^2+y^2}$ Determine flux through the sphere of Radius "R" whose centre is at origin

Sol/



$$d\vec{A} = \frac{dA\,(x\hat{i} + y\hat{j} + z\hat{k})}{\sqrt{x^2+y^2+z^2}}$$

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

$$= \frac{a\,dA\,\cancel{(x^2+y^2)}}{\cancel{x^2+y^2} \times \sqrt{x^2+y^2+z^2}}$$

$$d\phi = \frac{a\,dA}{\sqrt{x^2+y^2+z^2}}$$

$$\boxed{R = \sqrt{x^2+y^2+z^2}}$$

$$d\phi = \frac{a\,dA}{R}$$

PTO

1st Choice

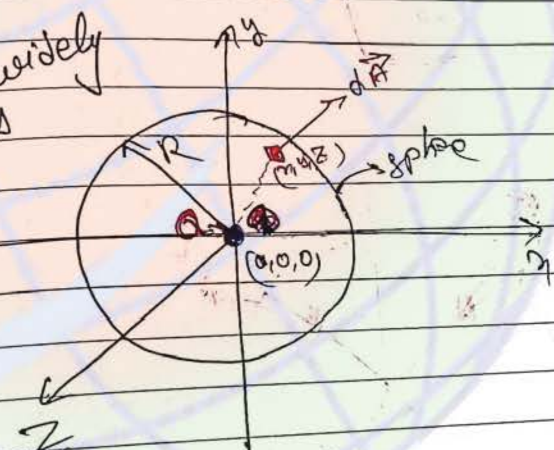
$$\phi = \frac{q\,dA}{R} + \frac{q\,dA}{R} + \frac{q\,dA}{R} + \frac{q\,dA}{R} + \cdots$$

$$= \frac{q}{R}\left[dA + dA + dA + \cdots\right.$$

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

$$\phi = 4\pi R q$$

Note ⇒ this question is widely used in gauss law



Determine flux through the sphere

$$\vec{E} = \frac{KQ\,(x\hat{i} + y\hat{j} + z\hat{k})}{(x^2+y^2+z^2)^{3/2}}$$

$$d\phi = \frac{KQ\,dA\,[x^2+y^2+z^2]}{(x^2+y^2+z^2)^2}$$

$$d\phi = \frac{KQ\,dA}{(x^2+y^2+z^2)}$$

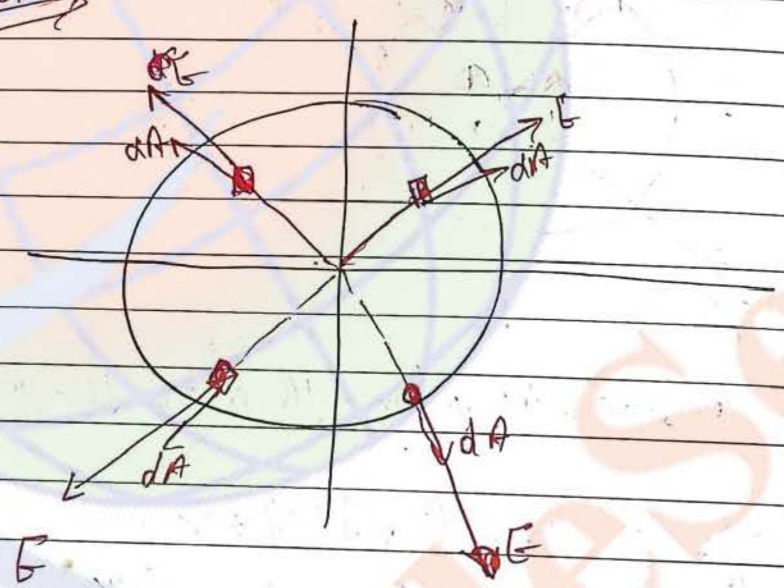
$$d\phi = \frac{KQdA}{R^2}$$

$$d\phi = \frac{KQ}{R^2}\left(dA + dA + dA + \text{——}\right)$$

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

$$\boxed{\phi = \frac{Q}{\epsilon_0}}$$

Alt ⇒



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

$$\phi = EdA + EdA + EdA + \text{——}$$

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

$$\Rightarrow \frac{Q}{4\pi\epsilon_0 R^2} \times 4\pi R^2 = \frac{Q}{\epsilon_0}$$

1st Choice

Gauss law → only closed surface के लिए applicable है।

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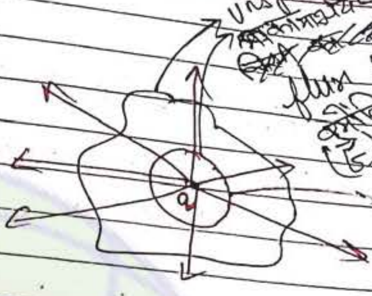
Definition →



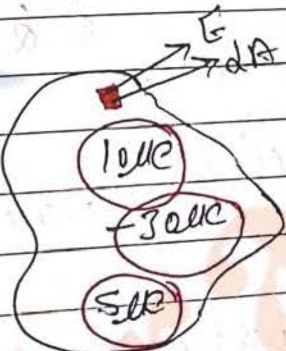
Unsymmetrical closed surface / sphere दोनों को flux same होगा क्योंकि दोनों में same charge है (q ही पास रहता है)

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

1) According to gauss law flux through any closed surface is given by the product of $\frac{1}{\varepsilon_0}$ and charge enclosed by that closed surface

$$\boxed{\oint_S \vec{E} \cdot d\vec{A} = \frac{q_{enclosed}}{\varepsilon_0} = \phi_{total}}$$

$\phi_{closed\ surface}$



10μC

20μC

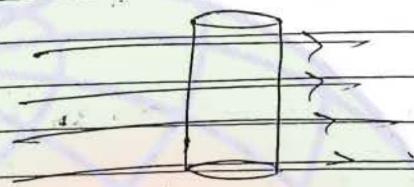
$q_{enclosed} = 10 + 5 - 30$

$= -15\mu C$

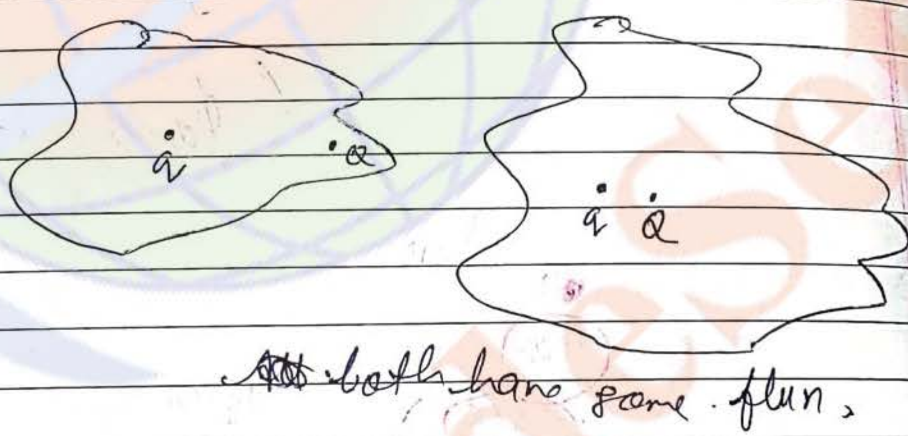
$\phi = \frac{-15 \times 10^{-6}}{\varepsilon_0}$

(-ve stands for flux अंदर की तरफ)

ii) In $\oint \vec{E}\cdot d\vec{A}$, E is electric field due to the charge present Inside as well as outside of the closed surface.



iii) flux through closed surface does not depend on shape, and size of closed surface and relative position of charges Inside closed surface.



both have same flux.

iv) By changing the position of charge or magnitude outside closed surface flux remain unchange but electric field can be change

* If a flux through closed closed surface is zero it is not necessarily that E at the surface is zero.
But if E is zero on the surface than flux must be zero.

ध्यान रखें dipole के case में "E" न तो axis पर zero होता है, और न ही equitorial plane पर। अर्थात dipole के case में E Infinity पर zero होता है। (LA)

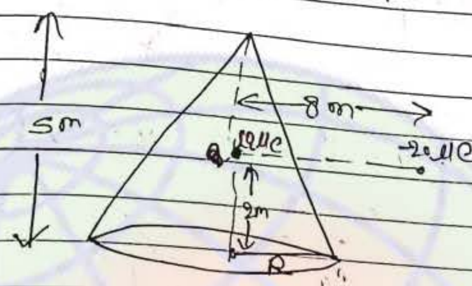
flux is zero but E is not zero

* flux through closed surface depend on surrounding medium also.
(ध्यान दें capacitor में पढ़ेंगे)

Application of Gauss law

1) Determination of flux using gauss law →

(Q.1)

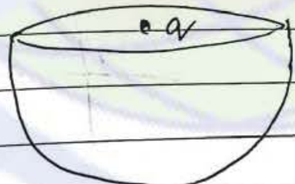


R = 4m

$$\phi_{through\ cone} = \frac{10\mu C}{\varepsilon_0} = \frac{10\times10^{-6}}{\varepsilon_0} C$$

इसें तो सिर्फ surface के अंदर का charge चाहिए बाकी बकवास है जो विद्यार्थी को भटकाने के लिए दिया गया है इसलिए आप सभी student ऐसे question में बकवास point से सतर्क रहें।

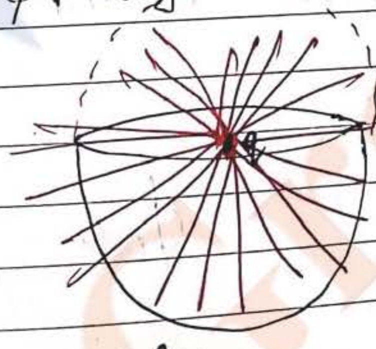
(Q.2)



open hemisphere

ϕ through curved surface of Hemisphere,

Sol^n



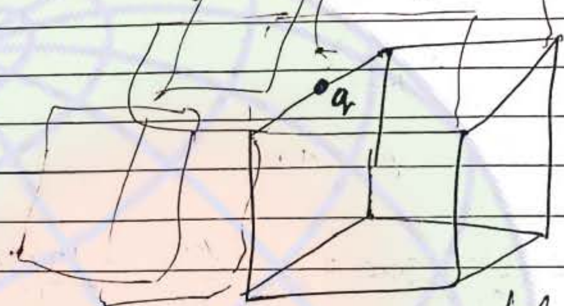
$$\phi_{sphere} = \frac{q}{\varepsilon_0}$$

$$\phi_{open\ hemisphere} = \frac{1}{2}\cdot\frac{q}{\varepsilon_0}$$

चूंकी gauss law सिर्फ closed surface के लिए Applicable है इसलिए ~~[illegible]~~ पहले आप closed surface consider करें। इस के बाद फिर A/q, "ϕ" find कर लें।

सार → एक charge पूरे ब्रह्मांड में सिर्फ $\boxed{\text{"}\frac{q}{\varepsilon_0}\text{"} \text{ flux}}$ देता है।

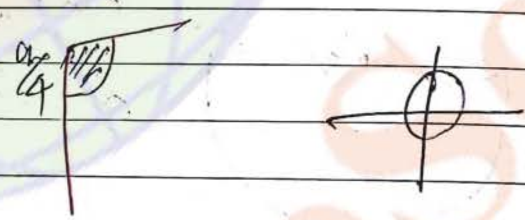
Q43. Determine flux through the cube



$\phi_{\text{by cube(बड़ा)}} = \frac{q}{\varepsilon_0}$

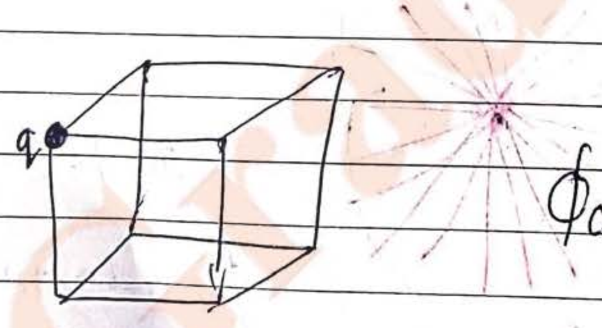
$\phi_{cube} = \frac{1}{4} \cdot \frac{q}{\varepsilon_0}$

Alt

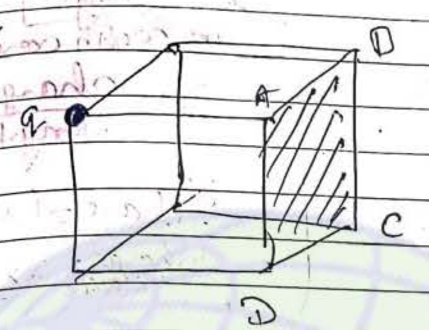


$\phi_{cube} = \frac{1}{4} \cdot \frac{q}{\varepsilon_0}$

Q44



$\phi_{cube} = \frac{1}{8} \cdot \frac{q}{\varepsilon_0}$



Determine ϕ through ABCD = ?

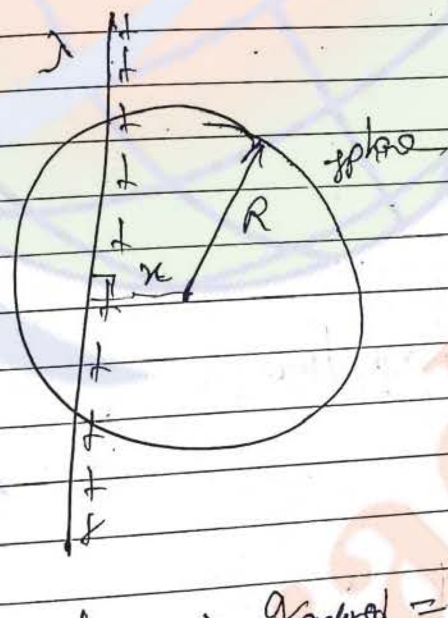
{charge जिस Plane में होता है उससे flux जाता ही नहीं है (अर्थात charge जिस Plane में होता है उसमें flux Zero होता है)}

Sol

$\phi_{\text{through ABCD}} = \frac{1}{3} \cdot \frac{q}{8\varepsilon_0}$

$= \frac{q}{24\varepsilon_0}$

{यदि तीन face से ही flux $\frac{q}{8\varepsilon_0}$ निकल रहा है तो आप Unitary method से एक face के द्वारा निकलने वाला flux पता कर सकते हैं}

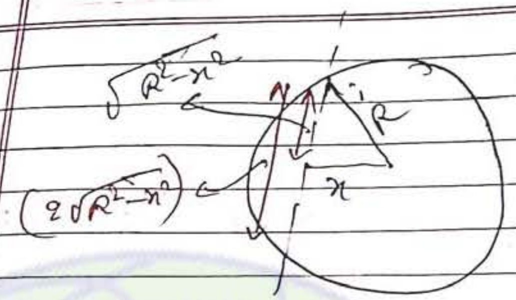


$\phi_{sphere} = \frac{\sqrt{3}\lambda R}{\varepsilon_0}$

$x = ?$

Sol

$\phi_{sphere} = \frac{q_{enclosed}}{\varepsilon_0} = \underbrace{\frac{\sqrt{3}\lambda R}{\varepsilon_0}}_{given}$



$$\boxed{\lambda = \frac{\text{mass}}{\text{length}}}$$

in concept of charge

$$\lambda = \frac{\text{charge}}{\text{length}}$$

so, charge $= (\lambda \times \text{length})$

$$\boxed{\text{charge enclosed} = \lambda \times 2\sqrt{R^2-x^2}}$$

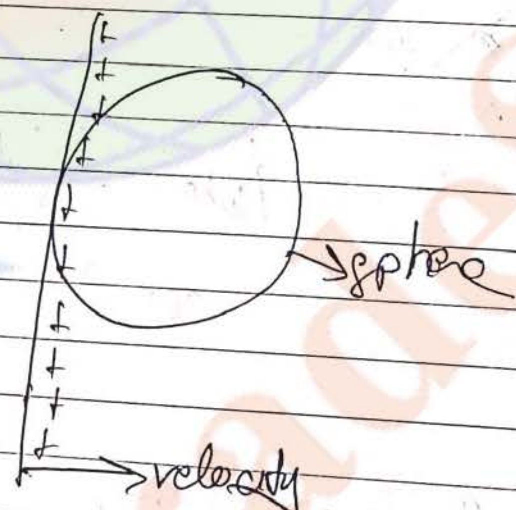
Now

$$\frac{\sqrt{3}\,\lambda R}{\cancel{\varepsilon_0}} = \frac{\lambda \times 2\sqrt{R^2-x^2}}{\cancel{\varepsilon_0}}$$

$$3\lambda^2 R^2 = \lambda^2\, 2^2 (R^2-x^2)$$

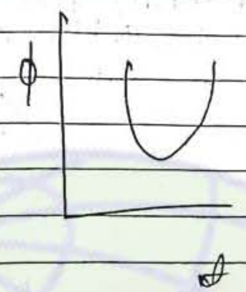
$$x =$$

Q.

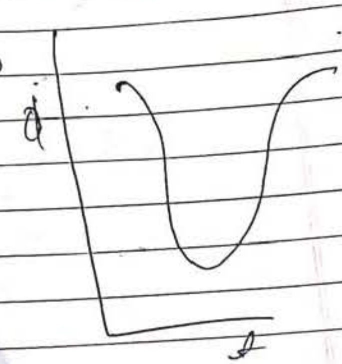


wire is moving with velocity v. How flux is varying with time?

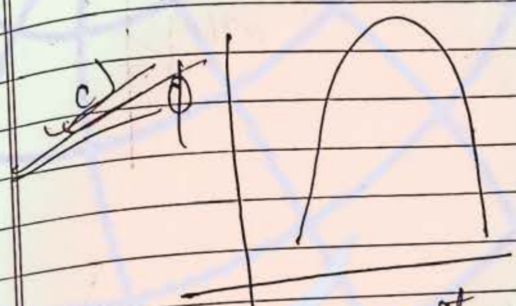
80 A)



B)



C)



D)

$\boxed{\phi = \frac{q}{\varepsilon_0}}$ → जैसे जैसे charge wire left से Right आएगा sphere में charge पहले बढ़ेगा और फिर इसके बाद घटेगा

Q

Determine flux through the cube?

method ① →

① यदि flux through किसी solid body (जैसे cube) का माँगें तो इस case में हमें $\vec{E}$ इसीर से देखने की कोई आवश्यकता नहीं है। इस case में हमें यह देखना है कि इस body की constant (सम्पर्क) में जो charge है उसी

cover (अंदर लाने के लिए) करने लिए कितने Identical body की आवश्यकता है उतने से भाग देकर flux find कर
1st Choice
Method IInd → मान लो आप Identical body से पूरा charge को cover (ढक सकता) नहीं कर पा रहे हैं तो पता कर लें कि उस body के द्वारा कितना charge enclosed किया जा रहा है

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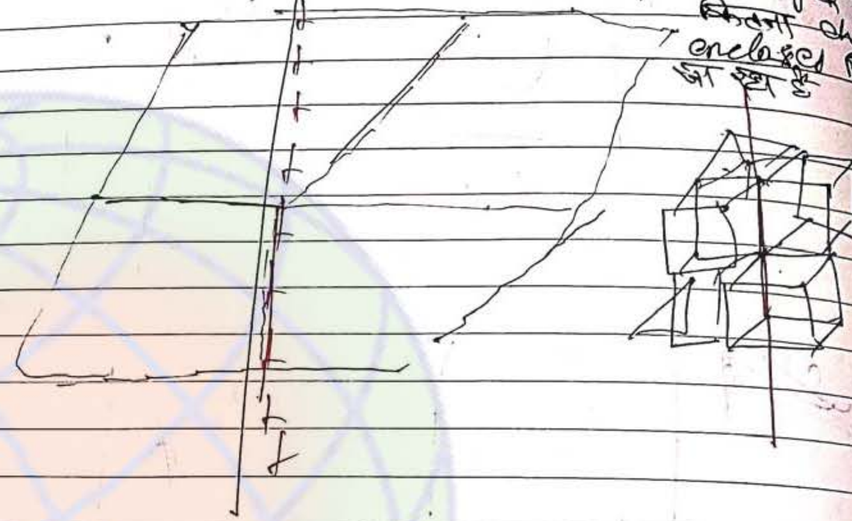
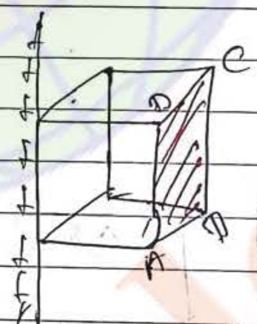
80|4



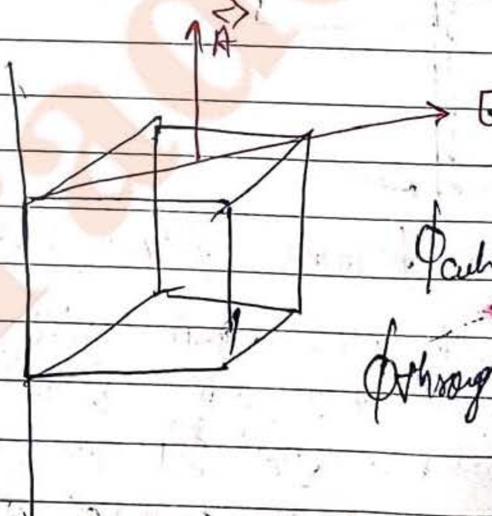
$$\phi_{cube} = \frac{1}{4} \times \frac{\lambda l}{\varepsilon_0}$$

(sol.)



Determine $\phi_{through\ ABCD}$

80|4



$$\phi_{cube} = \frac{\lambda l}{4\varepsilon_0}$$

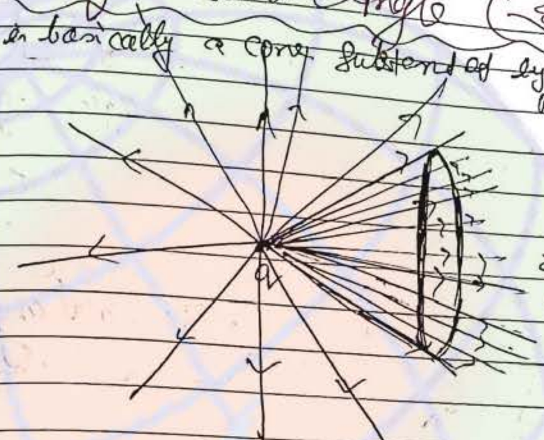
$$\phi_{through\ ABCD} = \frac{1}{2} \times \frac{\lambda l}{4\varepsilon_0}$$

$$= \frac{\lambda l}{8\varepsilon_0}$$

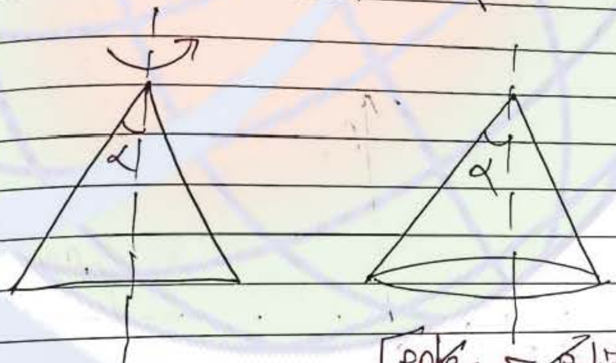
flux through the top and bottom surface of cube is zero because the $\vec{E}$ is $\perp$ to $\vec{A}$.
Flux through the two plane in which charge wire lies is zero. Therefore flux come only from two plane. $\phi_{ABCD} = \frac{1}{2} \times \phi_{cube}$
$= \frac{1}{2} \times \frac{1}{4} \times \frac{\lambda l}{\varepsilon_0}$
Therefore through one plane ABCD is half of total flux.

Concept of Solid Angle (घनिमा कोण)

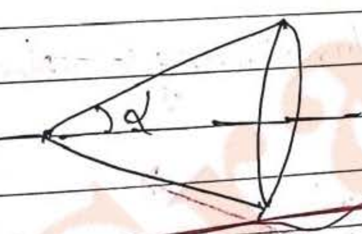
↳ It is basically a cone subtended by an area at the point of contact



point charge जो है वह total flux पूरे ब्रह्मांड में "$\frac{q}{\epsilon_0}$" देता है।



~~Sphere का solid angle = 4π~~

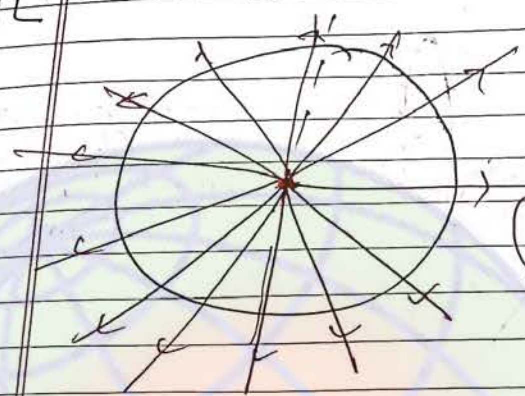


$$\boxed{\text{Solid angle of cone} = 2\pi\,[1 - \cos\alpha]}$$

where, → "α" is the semi vertical angle of the cone.

अ.द. साधारण angle से अलग है क्योंकि यह "3-D" angle है। जबकि हमलोग 2D angle पढ़ते हैं।

Solid angle is basically 3-D angle

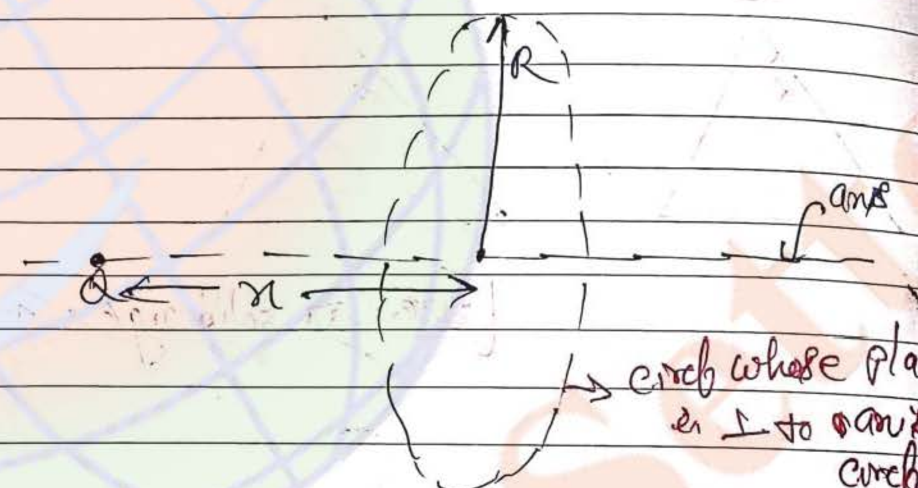


Angle = $\frac{Arc}{Radius}$

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

sphere का solid angle = 4π

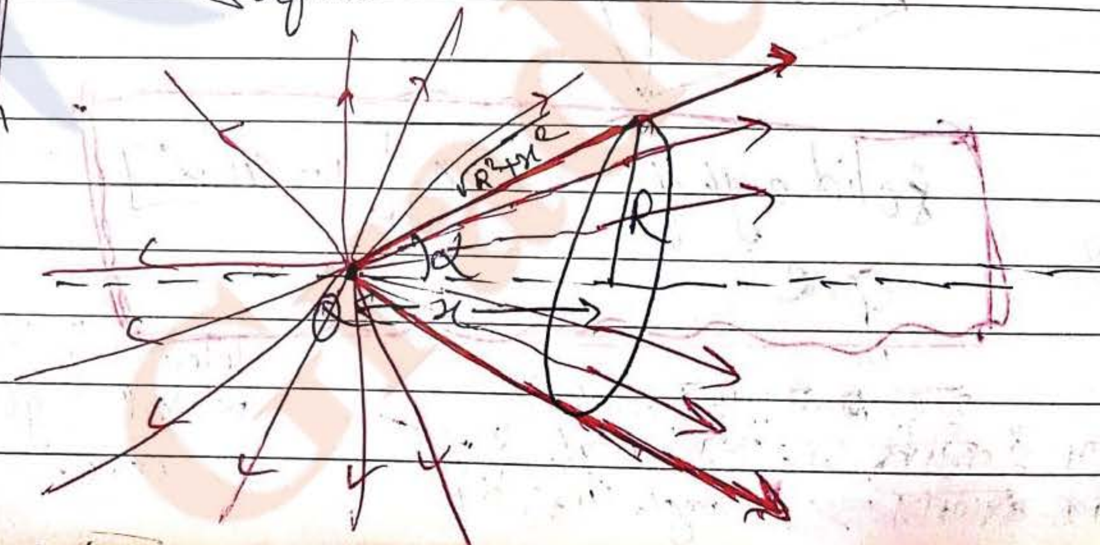
Sol.



circle whose plane is ⊥ to axis of circle

Determine flux through the circular surface.

Sol/n



Point charge in total flux is $\frac{q}{\varepsilon_0}$

unitary method

$4\pi \xrightarrow{\text{में flux}} \frac{Q}{\varepsilon_0}$ (sphere का solid angle 4π) (एक charge sphere में (अन्दर में) $\frac{q}{\varepsilon_0}$ flux देता है)

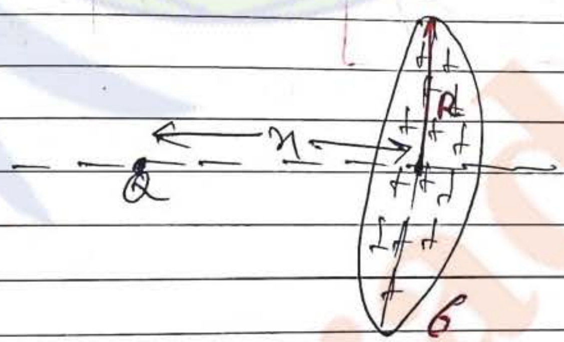
unit solid angle —— $\frac{Q}{4\pi\varepsilon_0}$

flux through solid angle $= 2\pi(1-\cos\alpha)$

$= \frac{Q}{4\pi\varepsilon_0} \times 2\pi(1-\cos\alpha)$

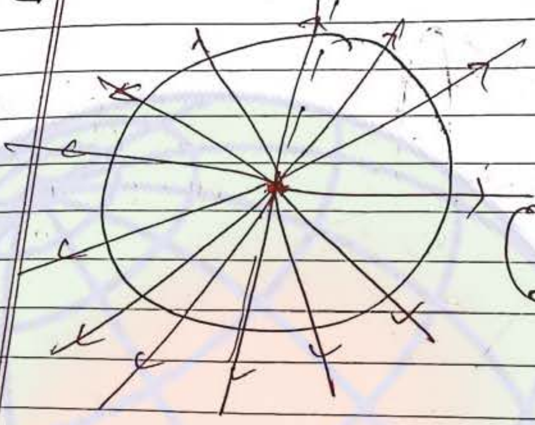
$$\boxed{\phi = \frac{Q}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{R^2+x^2}}\right]}$$

Good question



If flux through the disc is ϕ due to point charge "q".
Determine force on disk due to charge "Q".

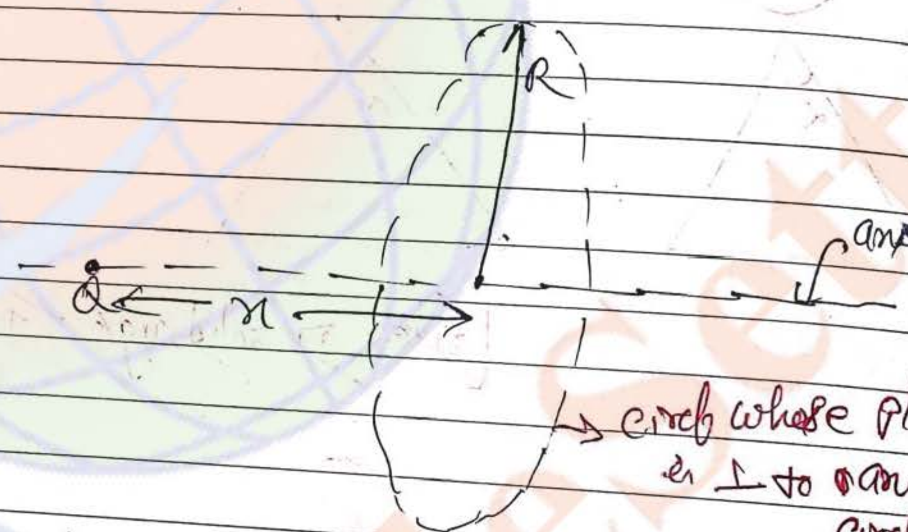
Solid angle is basically 3-D angle



$$\text{Angle} = \frac{\text{Arc}}{\text{Radius}} = \frac{4\pi R^2}{R^2} = 4\pi$$

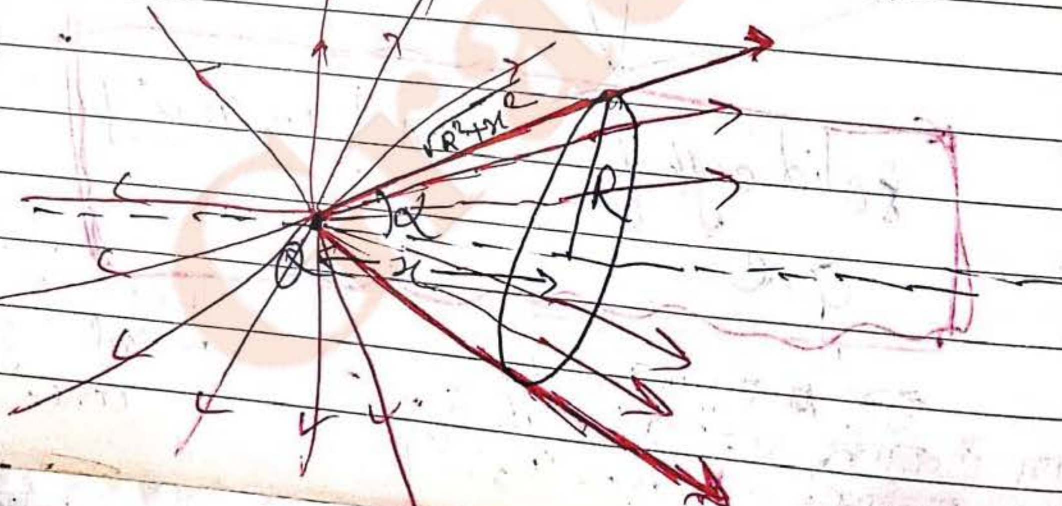
Sphere का solid angle $= 4\pi$

Sol.



Determine flux through the circular surface.

Sol



$$\boxed{\text{Point charge in total flux is } \frac{q}{\varepsilon_0}}$$

unitary method

$4\pi \xrightarrow{\text{में flux}} \frac{Q}{\varepsilon_0}$ (sphere का solid angle 4π) (एक charge sphere में (सर्वांग में) $\frac{q}{\varepsilon_0}$ flux देता है)

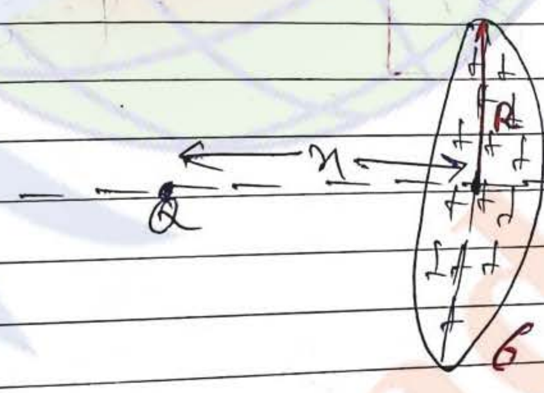
unit solid angle — $\frac{Q}{4\pi\varepsilon_0}$

flux through solid angle $= 2\pi(1-\cos\theta)$

$$= \frac{Q}{4\pi\varepsilon_0} \times 2\pi(1-\cos\theta)$$

$$\boxed{\phi = \frac{Q}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{R^2+x^2}}\right]}$$

Good question Imp.



If flux through the disc is ϕ due to point charge "q" Determine force on disk due to charge "Q".

Force on disc due to Q

A) $2\sigma\phi$ ~~(B)~~ $\sigma\phi$

C) $\frac{\sigma\phi}{2}$ (D) $3\sigma\phi$

Soln

$$E_{\text{due to disc}} = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{x^2+R^2}}\right]$$

$$F = QE$$

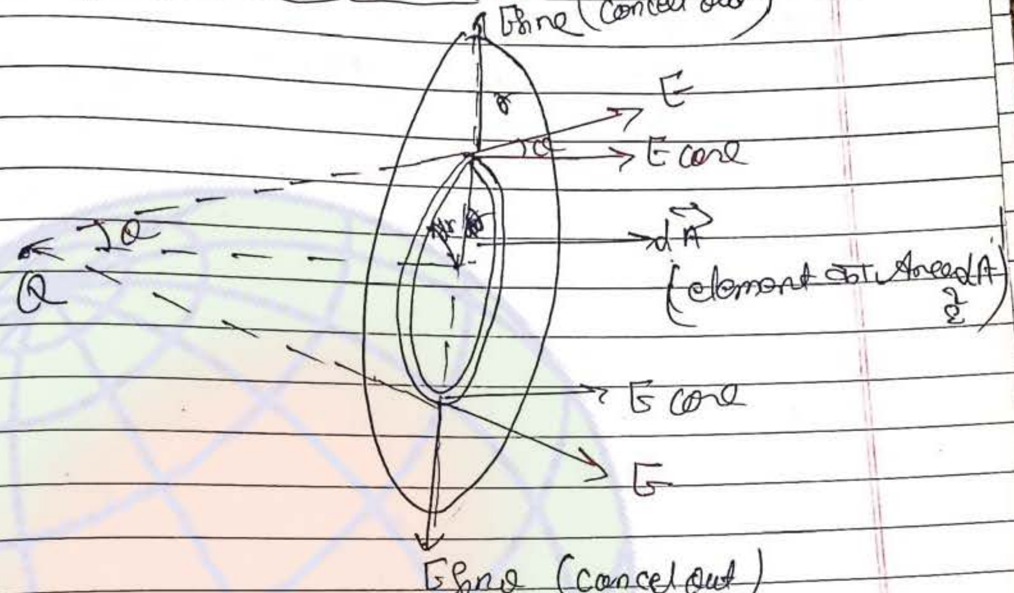
$$= \frac{Q\times\sigma}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{x^2+R^2}}\right]$$

By comparison

$$\boxed{F = \sigma\phi}$$

$$\because \phi = \frac{Q}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{x^2+R^2}}\right]$$

Detail of previous Question



$\because \sigma = \frac{\text{charge}}{\text{Area}}$

$\therefore dq = \sigma dA$

$\boxed{F = qE}$ or $\boxed{F = Eq}$

Here dq charge को "E" के E cosθ निकाला गया है और साथ E cosθ same direction में है।

$dF = E\cos\theta \times dq$

$= E\cos\theta \times \sigma dA$

$= E \times dA\cos\theta \times \sigma$

$\left(\because d\phi = E \cdot dA\cos\theta\right)$

$dF = \sigma d\phi$

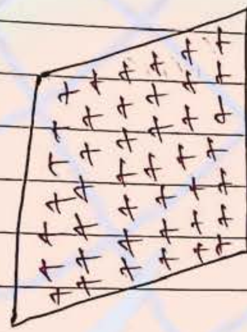
$F = \sigma(d\phi + d\phi + d\phi)$

so $\boxed{F = \sigma\phi}$

σ → sigma

Determination of E for various symmetric charge configuration:-

1) Uniformly ~~charge~~ large charge sheet
(Uniformly charge)(Insulating sheet)

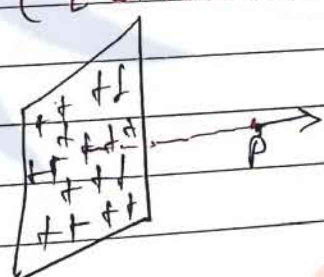


charge = Q
Area of one side = A

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

Step 1st -

1st determine direction of E by simple logic
(E is normal to sheet)



Step 2nd ⇒
Draw a closed surface which will pass through point "P" at which "E" is to be calculated.
This closed surface is known as "gaussian surface".

Step IIIrd ⇒

~~we have to draw~~

Determine flux through the gaussian surface.

~~Step IV~~

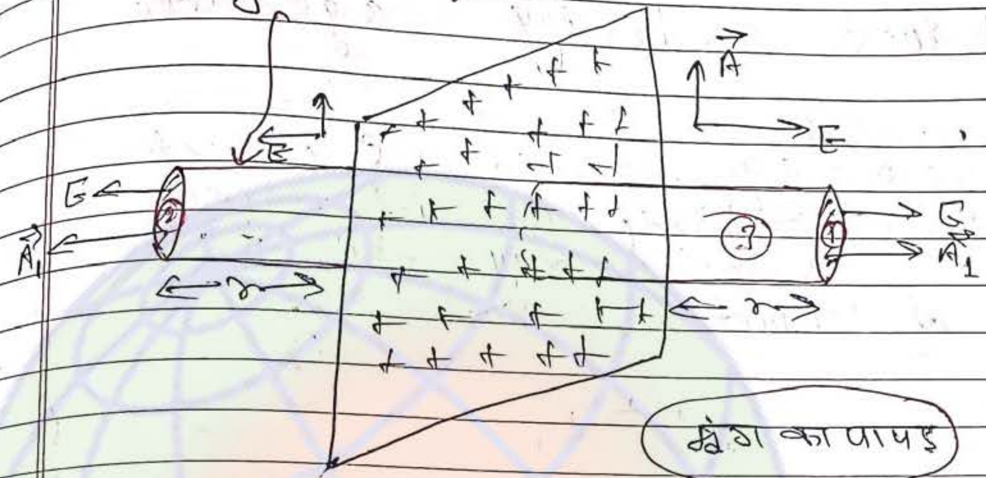
Step IVth –

Use gauss law

$$\boxed{\phi_{gaussian\ surface} = \frac{q_{enclosed}}{\varepsilon_0}}$$

E due to Insulating charge sheet ⇒

gaussion surface



ढंग का पापड़

काली मिर्च दोनों तरफ छिड़केंगे

$$\phi_3 = 0 \quad \{ \vec{E} \perp \vec{A}_1 \}$$

$$\phi_1 = EA_1\cos\theta = EA_1$$

$$\phi_2 = EA_1\cos\theta = EA_1$$

$$\phi = 2EA_1 \qquad \left(\because \sigma = \frac{q}{A} \right)$$

$$\frac{q_{encl}}{\varepsilon_0} = 2EA_1$$

$$\frac{\sigma A_1}{\varepsilon_0} = 2EA_1$$

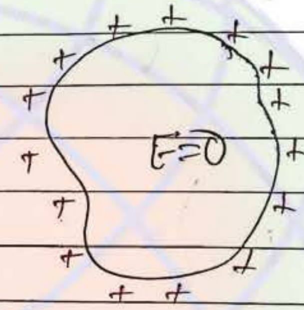
so,

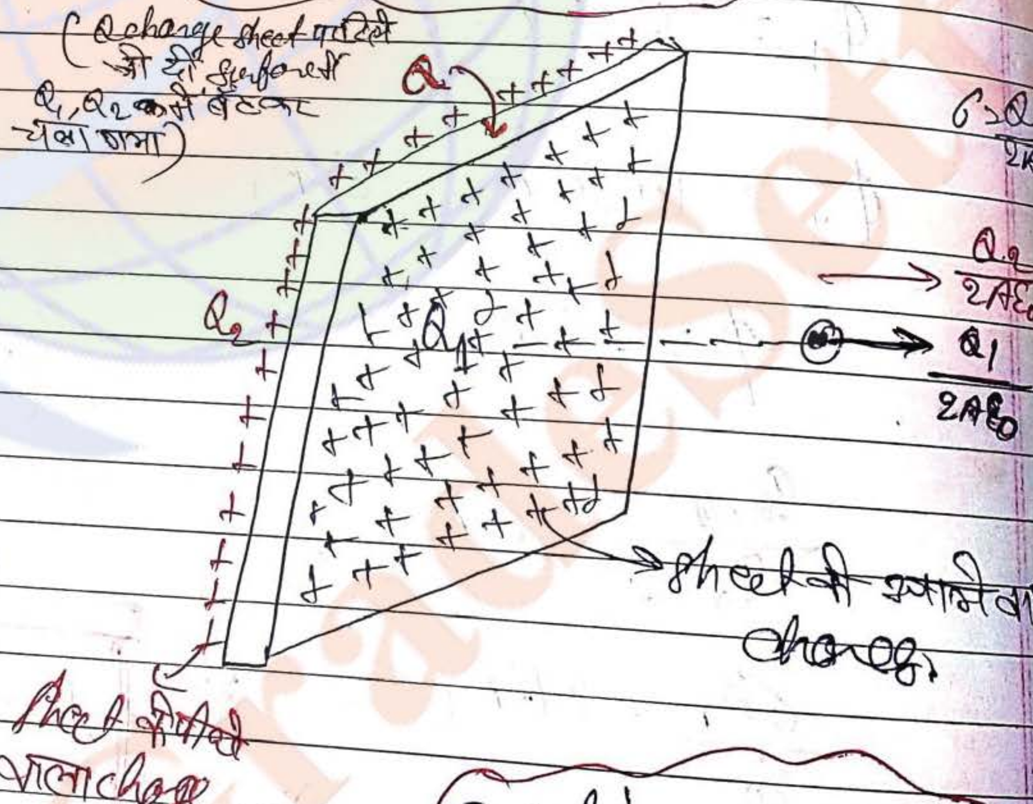
$$\boxed{E = \frac{\sigma}{2\varepsilon_0} \text{ (when charge density given)} \qquad E = \frac{Q}{2A\varepsilon_0} \text{ (when charge is given)}}$$

महत्व रखें और $\sigma = \frac{Q}{A}$ से इसेसा निकाल लें।

☆ E due to conducting charge sheet

when a charge is given to a conductor it distribute (charge) itself over its surface in such a way that "E" in bulk of conductor becomes zero.





Bread jam concept

$Q_1 + Q_2 = Q$

$$\boxed{\sigma = \frac{\text{charge}}{\text{"Total" Area जहाँ charge है}}}$$

यही definition है "σ" का याद रखें

So,

$$\sigma = \frac{Q}{2A}$$

$2A$ → क्योंकि Area पर charge distribute है।

◎ Conducting sheet can be assumed as a consist of "two charge layer's".

Therefore E due to conducting sheet is vector sum of E due to individual layer's

So,

$$\boxed{E = \frac{Q_1}{2A\varepsilon_0} + \frac{Q_2}{2A\varepsilon_0} = \frac{Q}{2A\varepsilon_0}}$$

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

Ex-1 → 1, 2, 3, 4,
Ex-2 → 1, 4, 11, 12, 13, 14
Ex-3 → 2, 3, 4,
~~Ex - 4 → 3, 2, 4~~

Note

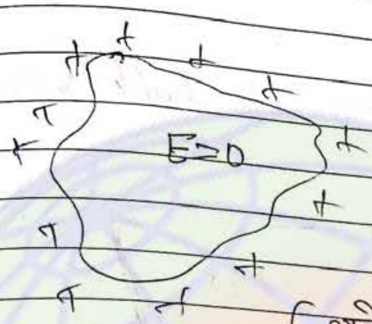
1) Electro field Intensity (E) due to conducting sheet does not depend on charge distribution on either surface of sheet (q_1 and q_2)

$$\boxed{E = \frac{Q}{2A\varepsilon_0}}$$

Q → charge on conducting sheet

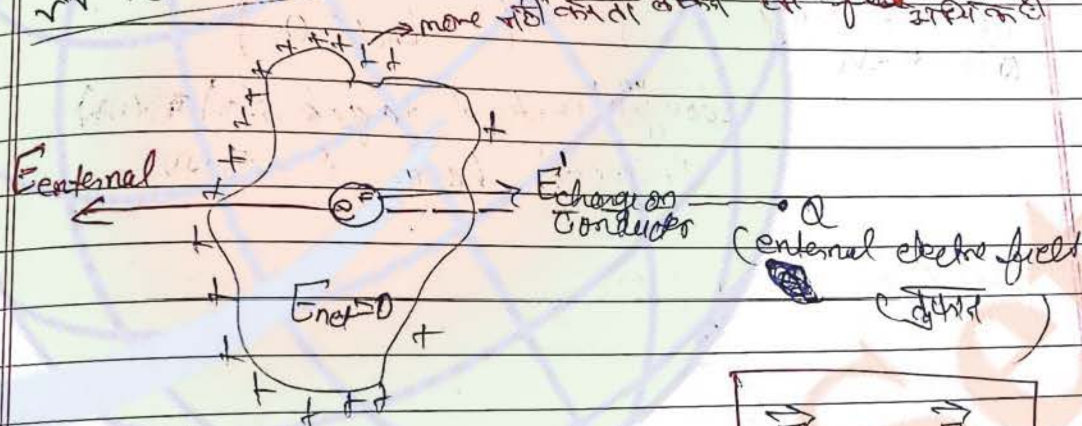
2.) ~~Formu~~
Formula of "E" for conducting sheet and charge layer is same in terms of charge. but in term's of "σ" formula is different

Concept of Induced charge →



(अकेला Conductor)

imp concept



$\boxed{\vec{E} = -\vec{E_1}}$

electrostatic condition

(electrostatic condition आने में 10^{-7} to 10^{-8} सेकंड का समय लगता है)

1) when charge conductor (or neutral conductor) is placed in a external electric field than due to Induction Induced charges comes on the Conductor

2) Induced charge does not change the charge on

1st Choice

conductor. but it change the distribution of charge on conductor surface to bring electrostatic condition.

2) In electrostatic condition in bulk of conductor (जहाँ-जहाँ conductor है)

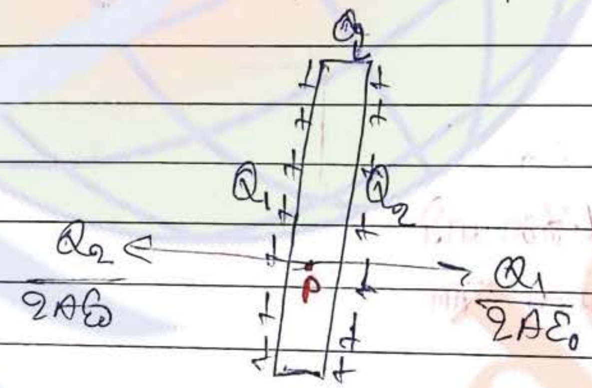
$$\boxed{\vec{E}_{external} + \vec{E}_{due\ to\ charge\ on\ surface\ of\ conductor} = 0}$$

बाहर की charge Q के कारण

$(\because E_{net} = 0)$

body में (external charge Q के) Induced charge के कारण

Q) Determine Q_1 and Q_2



Sol. At P

$E = 0$

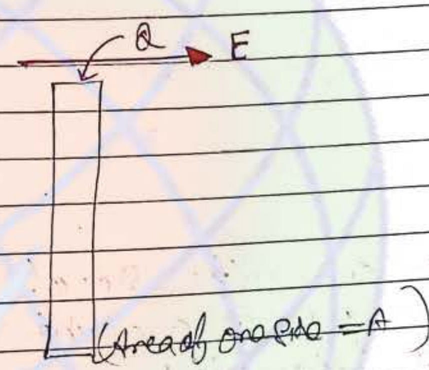
$$\frac{Q_2}{\cancel{2A\varepsilon_0}} = \frac{Q_1}{\cancel{2A\varepsilon_0}}$$

$Q_2 = Q_1$

$$Q_1 + Q_2 = Q$$

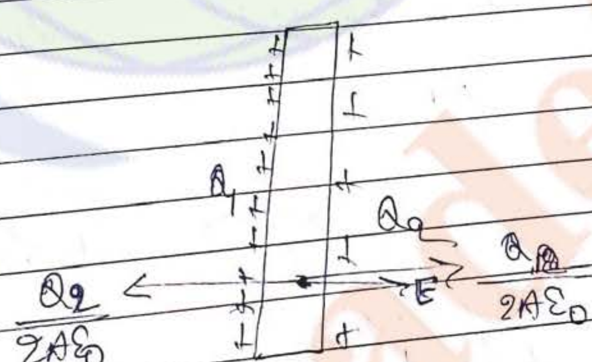
$$\boxed{Q_1 = Q_2 = \frac{Q}{2}}$$

(Q2) Now conducting sheet is placed in an external E.F as shown in figure



Determine charge on both surface of conducting sheet.

Sol/n



$$E + \frac{Q_1}{2A\varepsilon_0} = \frac{Q_2}{2A\varepsilon_0}$$

$$\frac{Q_1}{2A\varepsilon_0} + E - \frac{Q_2}{2A\varepsilon_0} = 0 \quad \text{---(1)}$$

$$Q_1 + Q_2 = Q \quad \text{— (8a)}$$

$$Q_1 = (Q - Q_2) \quad \text{— (2)}$$

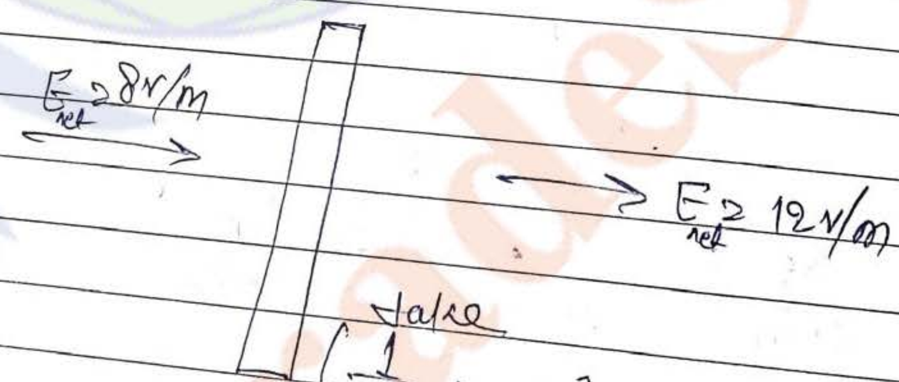
Now
from eq (2) and (1)

$$Q_1 = \frac{Q - 2E\varepsilon_0 A}{2}$$

$$Q_2 = \frac{Q + 2E\varepsilon_0 A}{2}$$

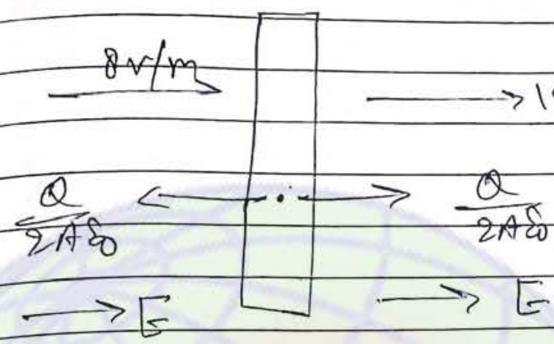
Concept:
whenever on either side of conducting sheet "E" given by examiner is not same in magnitude then it's mean that conducting sheet is placed in an external electric field

Example: Determine total charge on conducting sheet.



Sol: take $\left(\frac{1}{A\varepsilon_0} = 4\right)$

$$\frac{Q}{2A\varepsilon_0} \quad A \quad E \quad = \quad Q$$



(कोई भी direction मान सकते हैं)
(लेकिन इस बात का भी ध्यान रखें कि E_{net} किस direction में आना चाहिए। जिधर E_{net} आएगा उधर ही मानने का प्रयास करें)

$$\frac{Q}{2A\epsilon_0} + E = 12 \quad \text{--- (i)}$$

$$E - \frac{Q}{2A\epsilon_0} = 8 \quad \text{--- (2)}$$

eq (i) − eq (ii)

$$\frac{Q}{2A\epsilon_0} + \cancel{E} - \cancel{E} + \frac{Q}{2A\epsilon_0} = 12 - 8$$

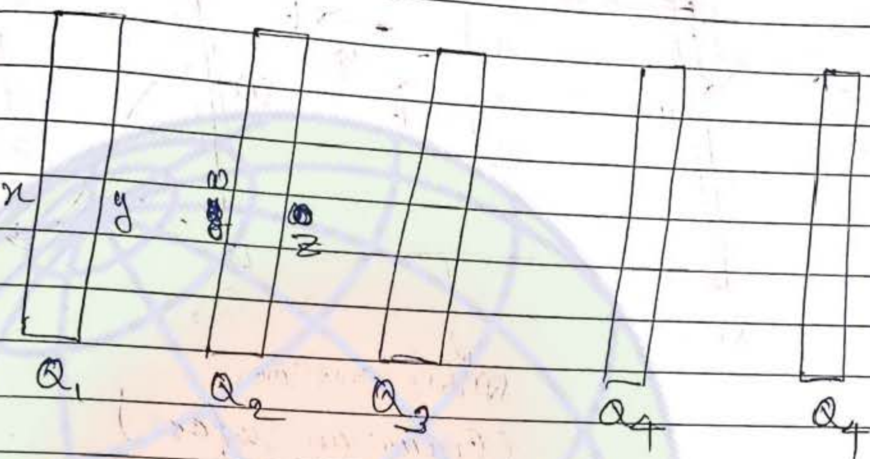
$$\frac{\cancel{2}Q}{\cancel{2}A\epsilon_0} = 4$$

$$4Q = 4$$

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

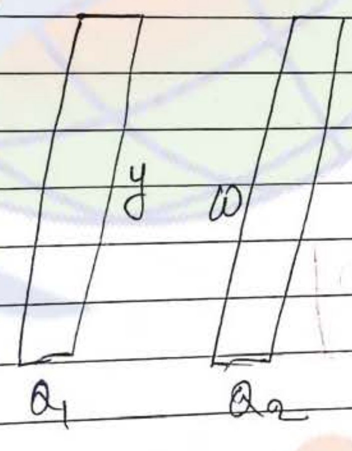
$$\boxed{Q = 1}$$

multiple Plate system and distribution of charge → n plates

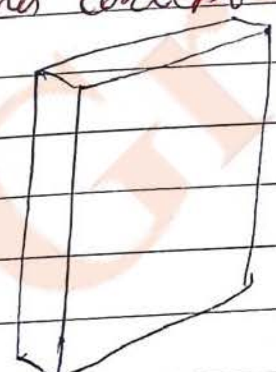


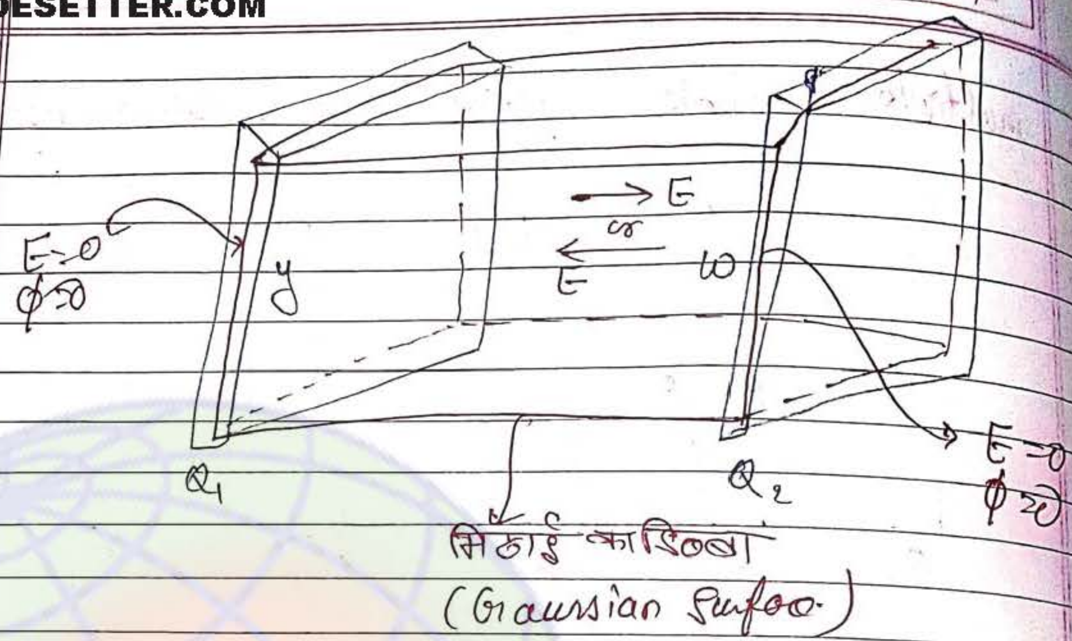
Board exam (proof)

1) Two facing surface of plate always have equal and opposite charge.



Proof of this concept using gauss law





$$\phi = 0$$

$$\frac{q_{enc}}{\varepsilon_0} = 0$$

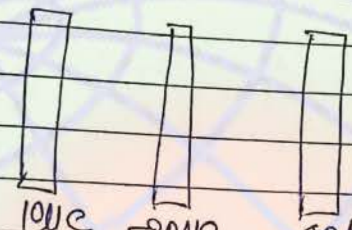
$$q_{en} = 0$$

$$y + \omega = 0$$

$$\boxed{y = -\omega}$$

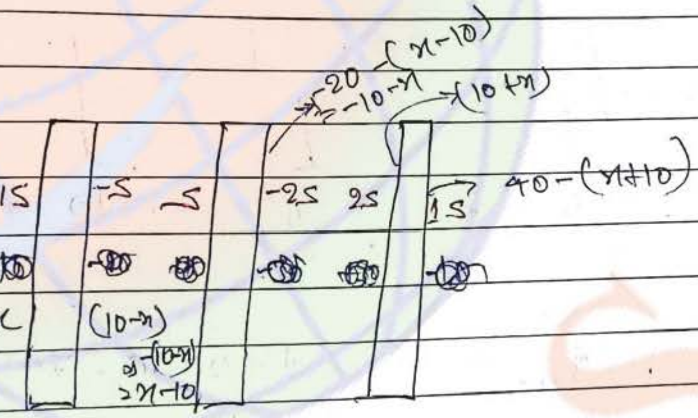
2.) Charge on outer surface of 1st plate and that on last plate are always same "when external electric field is absent".

eg1-



Determine charge on each surface of conducting plate

Sol^n



$$x = 30 - x$$

$$x = 15$$

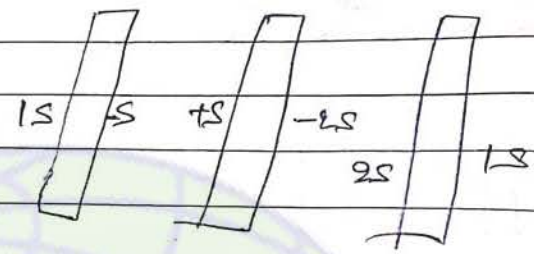
Trick ⇒ charge on outer surface of 1st and last plate is equal to

$$\boxed{Q_{outer surface} = \frac{Q_1 + Q_2 + Q_3 + \cdots}{2}}$$

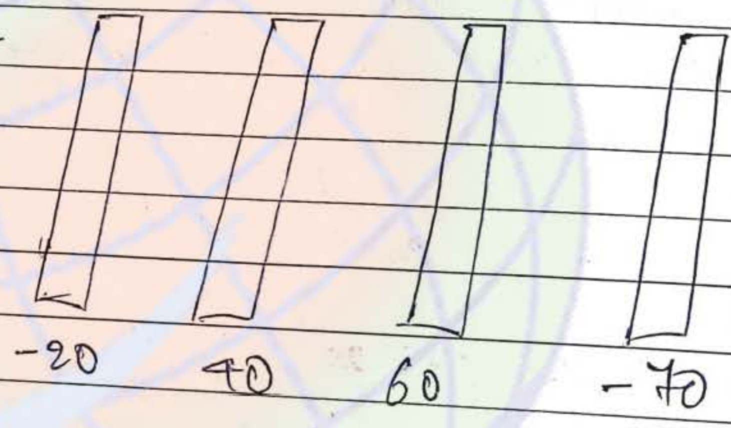
charge with sign

$$Q = \frac{10-20+40}{2}$$

$$= 15$$



Example

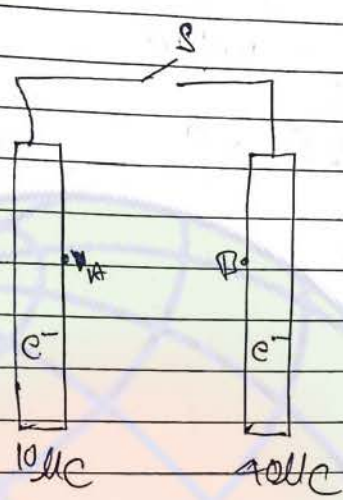


$$Q = \frac{-20+40+60-70}{2}$$

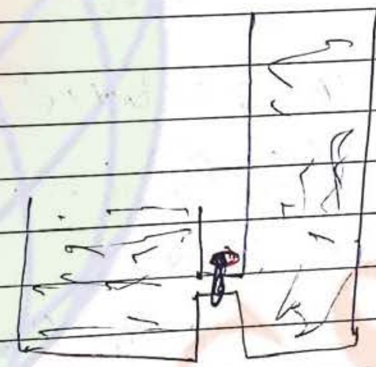
$$= \frac{100-90}{2}$$

$$= 5$$

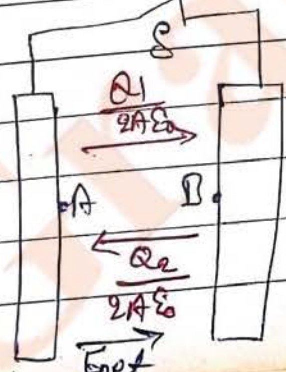
Q) Determine charge on both plate after closing of switch



Sol^n



when two conductor's are connected together sharing of charge take place b/w them till their potential become same.



sol

By conservation of charges –

$$Q_1 + Q_2 = 10 + 40$$

$$Q_1 + Q_2 = 50$$

Now

$$V_A = V_B$$

$$V_A - V_B = 0$$

$$E_{net} = \frac{Q_1 - Q_2}{2A\varepsilon_0}$$

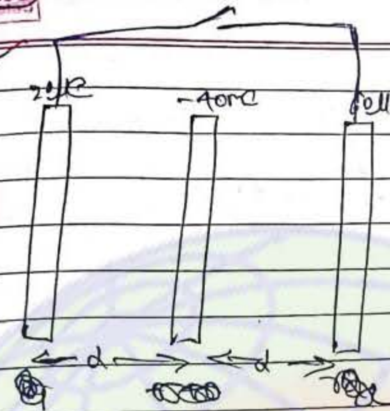
$$V_A - V_B = E_{net} \times d$$

$$\frac{(Q_1 - Q_2)d}{2A\varepsilon_0} = 0$$

$$Q_1 = Q_2$$

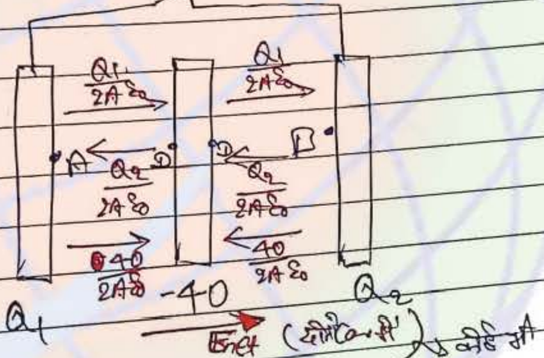
$$\therefore Q_1 = Q_2 = 25\,\mu C$$

Long Question



Determine charge on each plate after closing of switch.

Sol.



$$Q_1 + Q_2 = 20 + 60$$

$$Q_1 + Q_2 = 80$$

$$V_A = V_B$$

$$V_A - V_B = 0$$

$$V_A - V_D = \left(\frac{Q_1 + 40 - Q_2}{2A\varepsilon_0}\right) \times d$$

$$V_D - V_B = \left(\frac{Q_1 - Q_2 - 40}{2A\varepsilon_0}\right) d$$

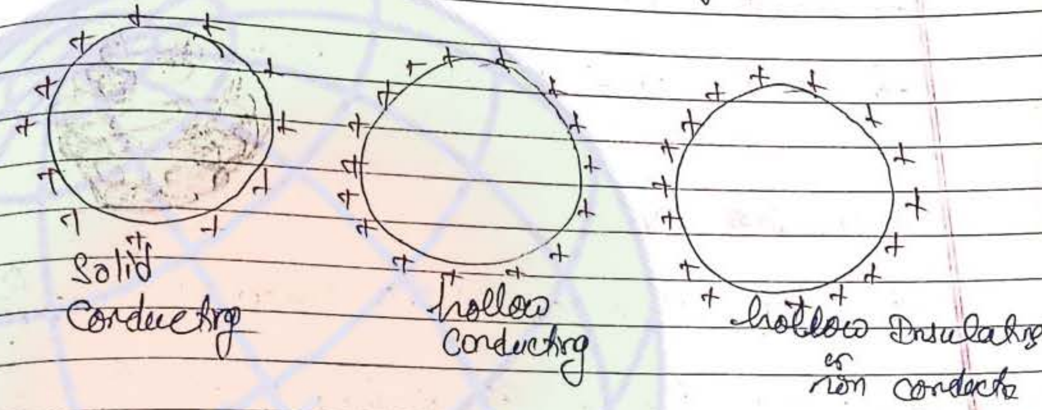
$$V_A - V_D = \left(\frac{2Q_1 - 2Q_2}{2A\varepsilon_0}\right) d = 0$$

80,

$$Q_1 = Q_2$$

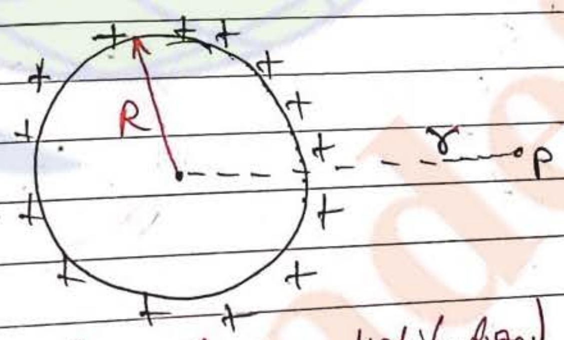
$$Q_1 = Q_2 = \frac{80}{2} = 40\,\mu C$$

E and V due to i) Solid conducting sphere
ii) hollow conducting sphere,
iii) hollow Insulating or non-conducting sphere



charge distribution on these three sphere is Identical therefore formula of E and V for these three sphere is same

Formula of E for giving sphere :—



$r \Rightarrow$ radius of P from Centre

(uniform charge distribution)

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

Now

if $r > R$, P is outside of sphere; $E = \frac{Q}{4\pi\varepsilon_0 r^2} = \frac{KQ}{r^2}$

if $r = R$, P is on the sphere; $E = \frac{Q}{4\pi\varepsilon_0 R^2} = \frac{KQ}{R^2}$

if $r < R$, P is Inside of sphere; $E = 0$

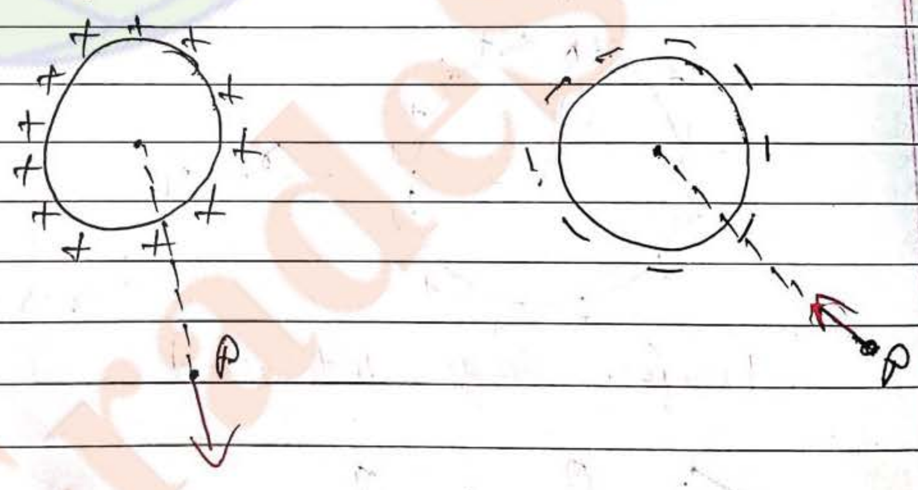
Formula of V :-

if $r > R$, P is outside the sphere; $V = \frac{Q}{4\pi\varepsilon_0 r} = \frac{KQ}{r}$

if $r = R$; P is on the sphere; $V = \frac{Q}{4\pi\varepsilon_0 R} = \frac{KQ}{R}$

if $r < R$; P is inside of sphere; $V = \frac{Q}{4\pi\varepsilon_0 R} = \frac{KQ}{R}$

Direction of E is radial →



Concept →

1) For the point outside and on the surface behavior of these sphere is like a point charge has whole charge of these sphere is placed at the centre.

2) (If point "P" is outside or on the surface then put whole charge at centre and use point charge formula.)

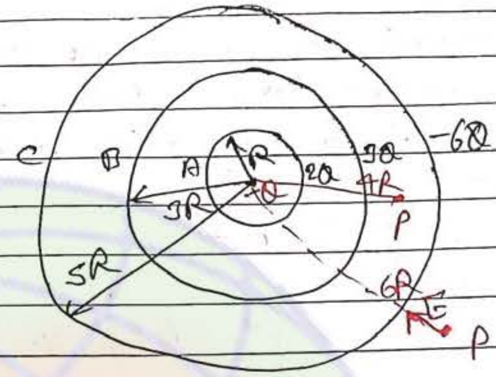
3) If point is Inside of sphere then E due to charge of that sphere is zero.

4) If point is Inside of sphere then potential due to charge of that sphere is given by a formula:

$$\boxed{V = \frac{K\,[\text{charge of that sphere}]}{\text{Radius of that sphere}}}$$

(ये dilogue याद करें)

Q.



Determine E and V at point 'P' for:-

a) $r = 6R$, $E = \frac{KQ}{(6R)^2}$

b) $r = 4R$

c) $r = 2R$

Sol^n a) $E = \frac{KQ}{(6R)^2}$

$V = \frac{K(-Q)}{6R}$

b) $E = \frac{5Q}{(4R)^2}$

$V = \frac{K5Q}{4R} + \frac{K(-6Q)}{5R}$

c)

1st Choice

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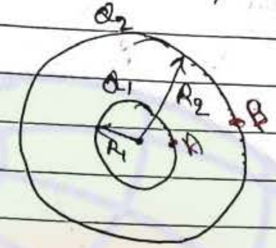
Date / /

Q. Two Conducting hollow sphere. Determine P.D b/w these spheres.



Sol/

Conclusion:
Conductor's are equipotential therefore potential ~~on conductor~~ at any point on the conductor means potential at any point on the surface of conductor is same

$$V_A = \frac{KQ_1}{R_1} + \frac{KQ_2}{R_2}$$

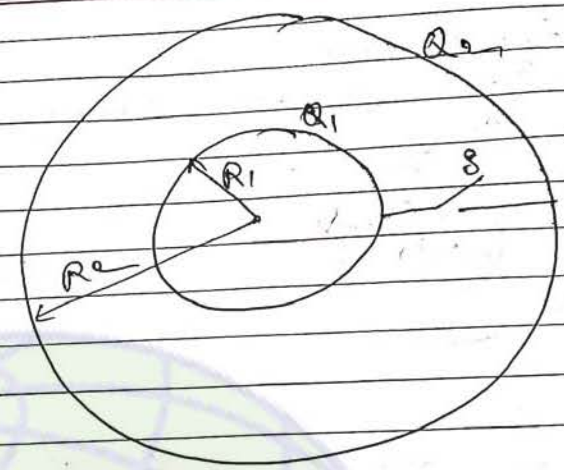
$$V_B = \frac{K(Q_1+Q_2)}{R_2}$$

$$\boxed{V_A - V_B = KQ_1\left[\frac{1}{R_1} - \frac{1}{R_2}\right]}$$

In case of two Concentric sphere P.D. b/w sphere's depend on the charge's of Inner sphere not on Outer sphere.

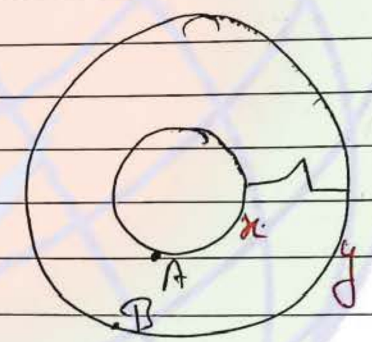
Suggest - Sheet Ex 1 Q No 8

Eg.



Determine charges of both spheres after closing of switch.

Sol^n



$$x + y = Q_1 + Q_2 \quad \text{---(1)}$$

$$V_A = V_B$$

$$\frac{kx}{R_1} + \frac{ky}{R_2} = \frac{k(x+y)}{R_2}$$

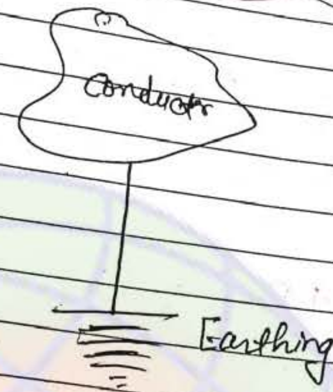
$$V_A - V_B = kx\left[\frac{1}{R_1} - \frac{1}{R_2}\right] = 0$$

$$x = 0$$

$$y = Q_1 + Q_2$$

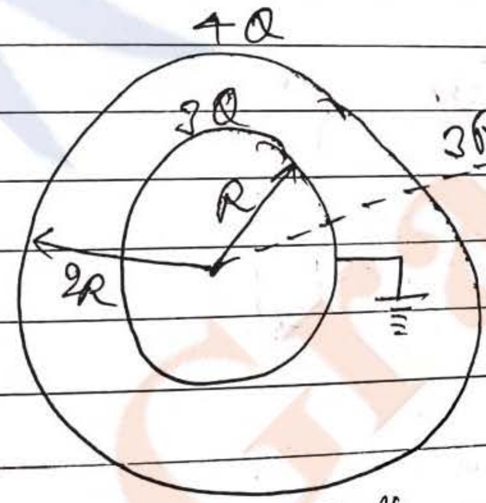
Principle of tensorgraph generator →

Concept of earthing or Grounding →



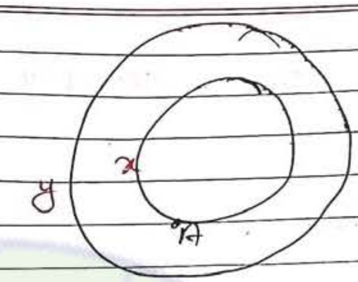
* On ~~earth~~ earthing sharing of charge take place b/w conductor and earth due to which charge on conductor get changed.
* Potential of earth is taken as zero because it is very large size conductor.
* after earthing potential of conductor is becomes zero.

Q.



Determine "E" at "P" after closing of Switch.

Sol^n



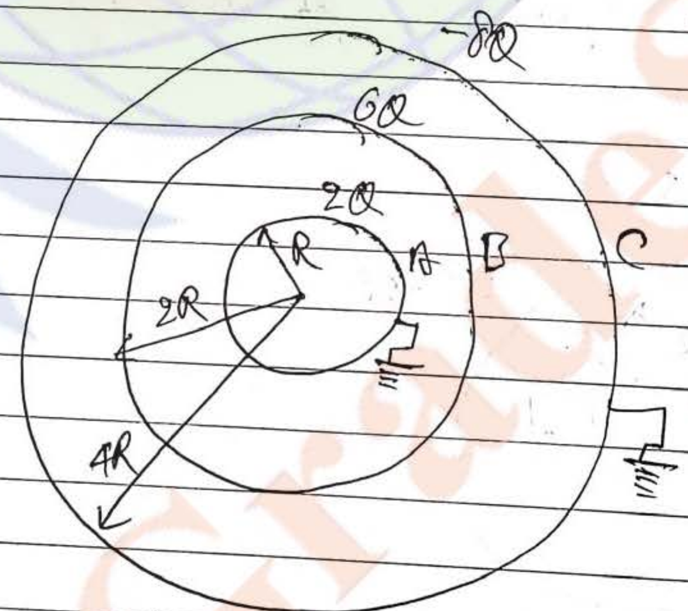
$$\frac{Kx}{R} + \frac{K4Q}{2R} = 0$$

$$\boxed{x = -2Q}$$

$$E = \frac{K[-2Q + 4Q]}{(3R)^2}$$

$$= \frac{K \times 2Q}{9R^2}$$ Ans

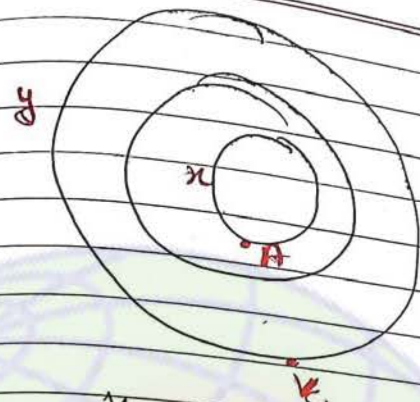
Q2.



Determine charge on A and C after closing of both switch.

H.W → Ex-3, Passage (1) ...
JOS Ex-2, O No → 8, 9,
Ex-3, 13, 10, 9, 8, 6;

(Q6)



$V_A = 0$

$$\frac{Kx}{R} + \frac{K6Q}{2R} + \frac{Ky}{4R} = 0 \quad \text{—(i)}$$

$$\frac{K(x+y+6Q)}{4R} = 0 \quad \text{—(ii)}$$

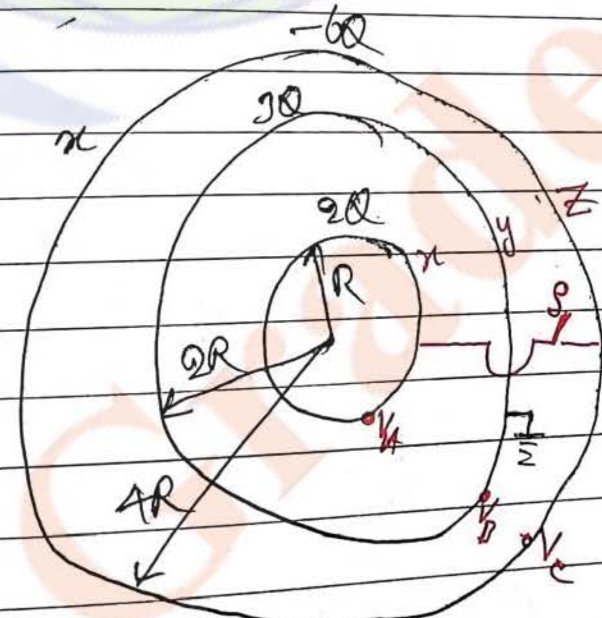
from eq (i) and (ii)

find

$x = $

$y = $

(Q8.)

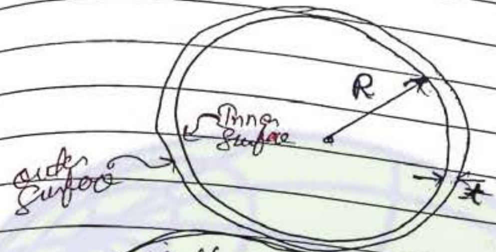


$V_B = 0$ —(i)

$V_A = V_C$ (ii)

$x + Z = 2Q - 6Q$ (iii)

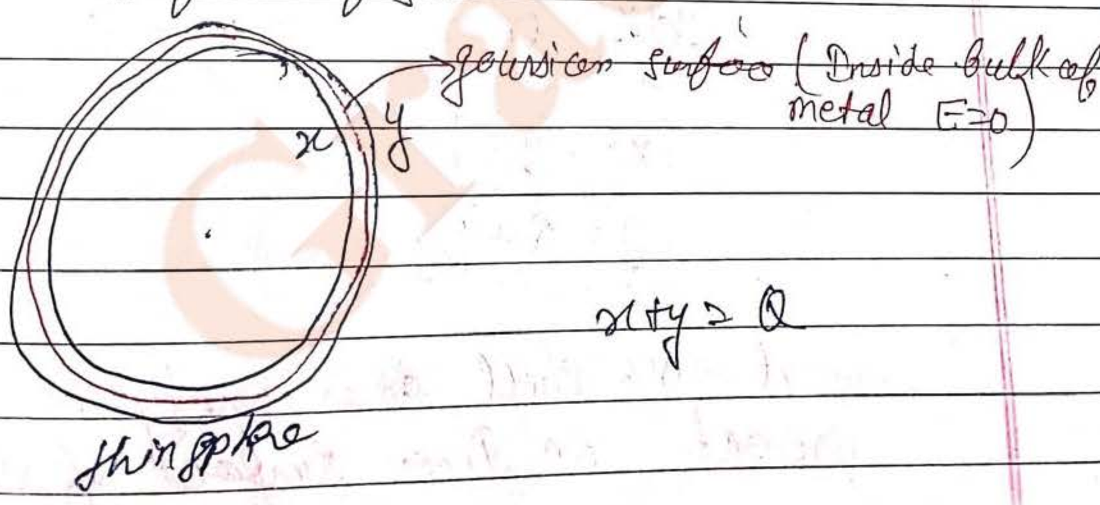
Distribution of charge on the surface of shell →



Hollow sphere is known as shell.

Q) ~~thick~~ shell. In thin shell charge Q is given to the shell. determine the charge on Inner and outer surface of shell.

Sol



$x + y = Q$

$x + y = Q$

$E = 0$

$\phi = 0$

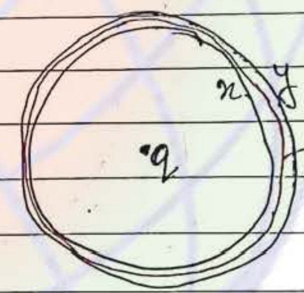
$q_{enclosed} = 0$

$x = 0$

$y = Q$

eg) A charge "q" is placed at centre of previous shell. Determine charge on Inner and outer surface of shell.

Solⁿ



$x + y = Q$

$E = 0$

$\phi = 0$

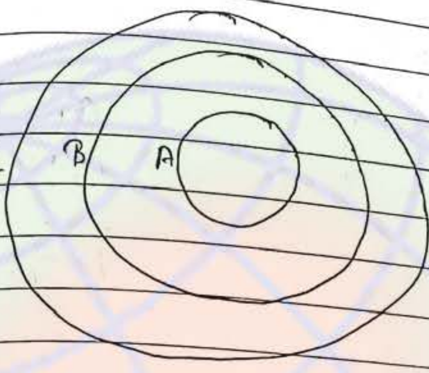
$\frac{q + x}{\varepsilon_0} = 0$

$\boxed{x = -q}$

$\boxed{y = Q + q}$

concept! → If shell is empty no charge is present on Inner surface of shell.

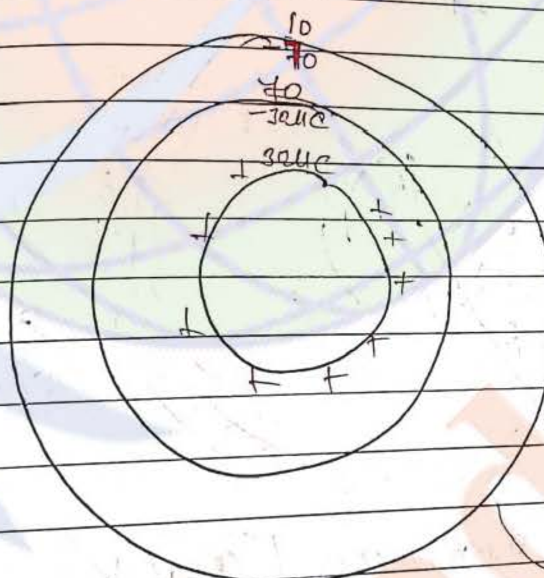
ii) If a charge "q" is present the shell then Induced charge "−q" will come on Inner surface of shell. However total charge on the shell remain same.



Thin conducting shell
shell A → 30μC
B → 40μC
C → −60μC

Determine charges on each surface of each shell.

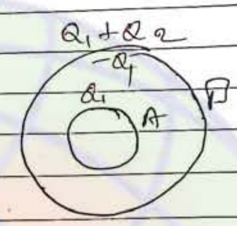
Sol



Concept →
Facing surface of concentric shell always have equal and opposite charges.

Q. charge on shell A is "q_1" and on shell B is q_2. Ratio of charge on outersurface of A to outer surface of B is 1:3. Determine $\frac{q_1}{q_2}$?

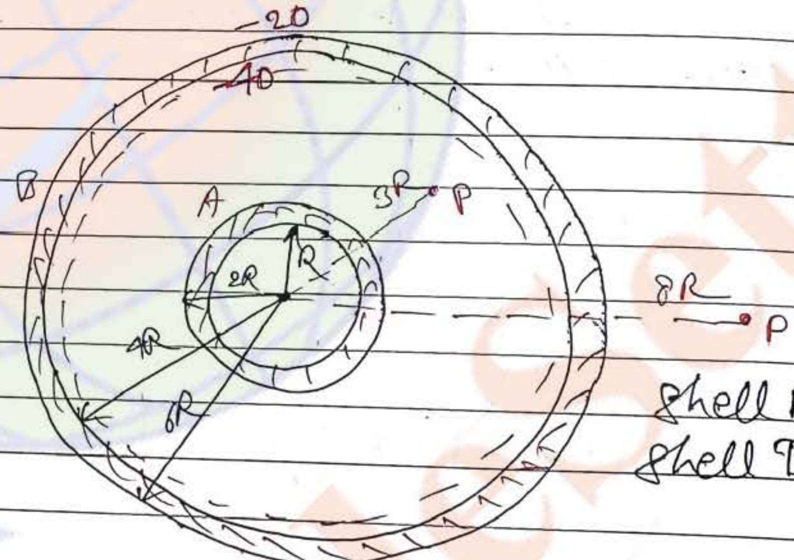
80/4



$$\frac{Q_1}{Q_1+Q_2} = \frac{1}{3}$$

$$\boxed{\frac{Q_1}{Q_2} = \frac{1}{2}}$$

good conceptual question



Shell A = 40 μC
Shell B = 60 μC

At P Determine E and V
at
(a) $r = 8R$
(b) $r = 3R$

Sol
a) $r = 8R$

$$E = \frac{K[40+60]}{8R^2}$$

$\Rightarrow \cancel{\frac{K \times 80}{80}}$

$\Rightarrow \frac{K \times 20}{(8R)^2}$

$V = \frac{K \times (-20)}{8R}$

11 T 2013 (b) E at P, $r = 3R$

$E = \frac{K \times 40}{(3R)^2}$

{ और जब हमें Potential ही निकालना हो और charge shell के अंदर रखा हुआ हो तो इस case में ही thick shell का दोनों पर्त का "V" निकालना होगा।

$V = \frac{K \times 40}{3R} + \frac{K(-40)}{4R} + \frac{K(-20)}{6R}$

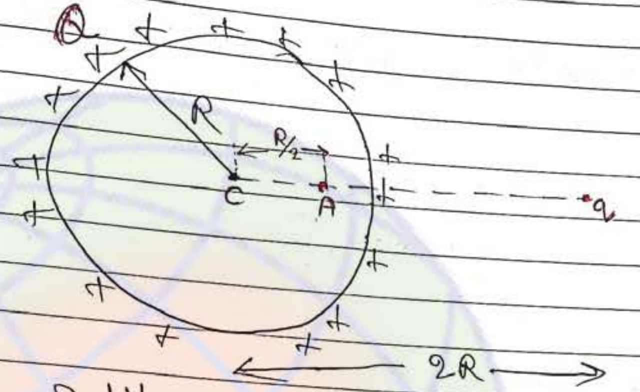
Concept ⇒ i) In case of thick shell if we are interested to determine potential inside shell than we have to determine charges on inner and outer surface of that shell.

ii) After knowing charges on both surface determine potential at that point by individual surface sphere and than add them algebrically in this way we will able to find out potential due to shell inside "A".

iii) बाकी सभी cases के लिए No tention of inner and outer surface charges.

Question's of Induced charge and conducting sphere

Physics olympiad 2011



Solid conducting sphere

considering the Induction effect of charge "q" on conducting sphere.

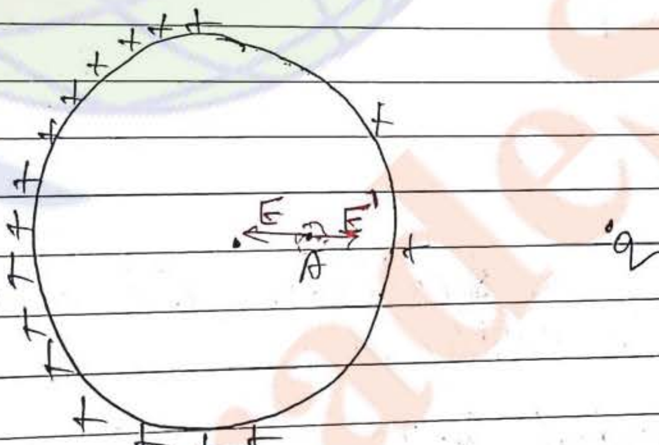
Determine i) E at A

ii) E at A due to charges on sphere

iii) V at A

iv) V at A due to charges on sphere.

sol^n



(i) E at A = 0 (Due to electrostatic condition)

ii) At "A" =

$\vec{E}$ due to charge q + $\vec{E}$ due to charge on sphere ⇒

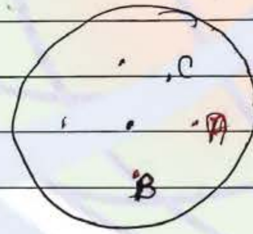
$$E' = \frac{kq}{\left(2R - \frac{R}{2}\right)^2}$$

iii) V at A =

$$V_{at\,A} = V_{due\ to\ q\ at\ A} + V_{due\ to\ charge\ on\ sphere\ at\ A}$$

$$= \frac{kq}{\left(2R - \frac{R}{2}\right)} +$$ ~~हम नहीं लिख सकते~~ इसे नहीं लिख सकते क्योंकि →

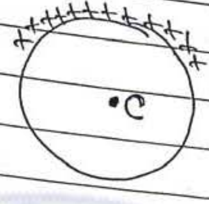
because distribution of charge ~~on the charge~~ on the sphere is non-uniform we dont have formula of "V" ~~at~~ for such non-uniform distribution at point "A".



In conductor E is Zero due to charge "q" and "Q".

Potential due to ~~small~~ "q" and "Q" is same at each point in conducter.

If distribution of charge on the sphere is non-uniform we can determine potential at the centre of sphere due to charge on sphere



$V_C = \frac{KQ}{R}$

यदि charge distribution non-uniform है और हमें "V" at any point inside the shell (except centre) निकालना हो तो इस case में हम "V" at centre ही निकालते हैं और यह centre के अलावा point पर same रहता है

$V_C = V_A$

Now

$V_C = V_{\text{due to } q \text{ at } A} + V_{\text{due to charge on sphere at "A"}}$

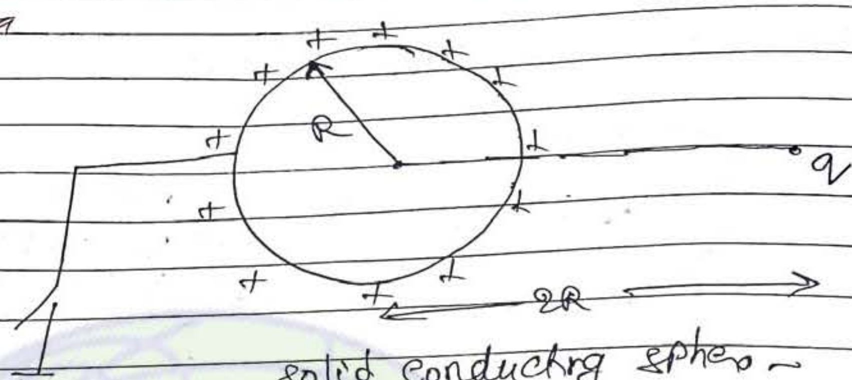
$$\boxed{V_A = \frac{Kq}{2R} + \frac{KQ}{R}}$$

iv) $V_{\text{due to charge on sphere at } A} = V_A - V_{\text{due to } q \text{ at } A}$

$$= \frac{Kq}{2R} + \frac{KQ}{R} - \frac{2Kq}{3R}$$

v) ——

IIT 99



solid conducting sphere -

Determine the charge on sphere after closing of switch.

Sol^n

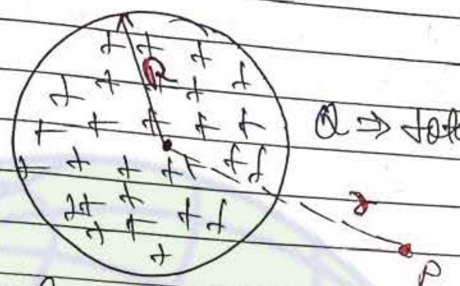
$$\frac{Kx}{R} + \frac{Kq}{2R} = 0$$

Attention

$$x = \frac{-q}{2}$$

जब भी sphere के सामने एक charge हो तो determine potential ~~also~~ always at centre.

E and V due to non-conducting sphere →



$Q \Rightarrow$ total charge

Charge distributed within the volume of sphere.

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

ρ = charge per unit volume
(volume charge density)

Formula of E →

if $r > R$; $E = \frac{kQ}{r^2}$

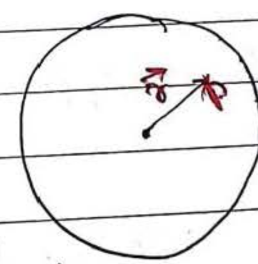
if $r = R$; $E = \frac{kQ}{R^2}$

if $r < R$; $E = \frac{\rho r}{3\varepsilon_0}$, (without sign)

Now

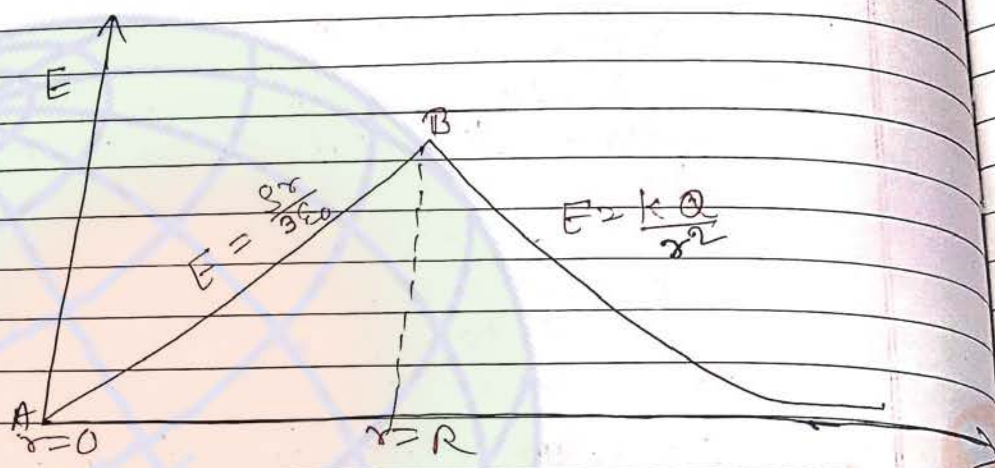
$$\vec{E} = \frac{\rho r}{3\varepsilon_0}\hat{r}$$

$$= \frac{\rho r \vec{r}}{3\varepsilon_0 r} = \frac{\rho \vec{r}}{3\varepsilon_0}, \text{ with sign}$$



so

$$\boxed{\vec{E} = \frac{\rho r \hat{r}}{3\varepsilon_0}}$$, "ρ" with sign



[E is max at the surface, slope of line $AB \propto \rho$]

Formula of "V" →

if $r > R$; $V = \frac{kQ}{r}$

if $r = R$; $V = \frac{kQ}{R}$

if $r < R$; $V = \frac{kQ[3R^2 - r^2]}{2R^3}$

$r = 0$ at centre

at r=0, at center:
$$V_{centre} = \frac{3kQ}{2R}$$

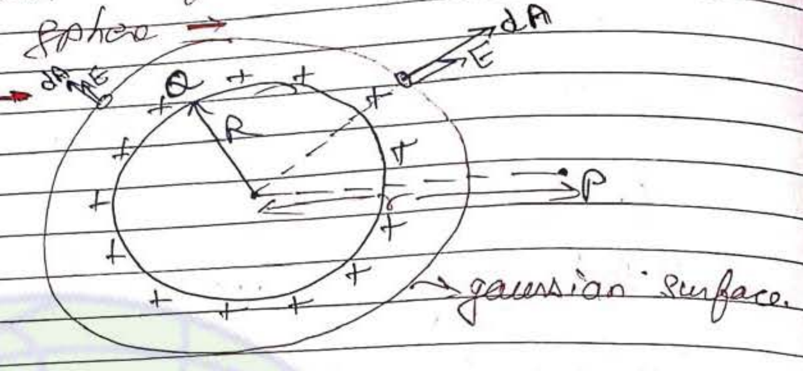
at r=R, V at surface
$$V = \frac{kQ}{R}$$

Put charges with sign.

$$\boxed{V_{at\ centre} = 1.5\ V_{surface}}$$

Derivation of E due to solid conducting sphere →

Case III :- $r > R$



Direction of E is radial

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

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

$$\phi = [E\,dA + E\,dA + \cdots]$$

$$= E[dA + dA + dA + \cdots]$$

$$\phi = E \times 4\pi r^2$$

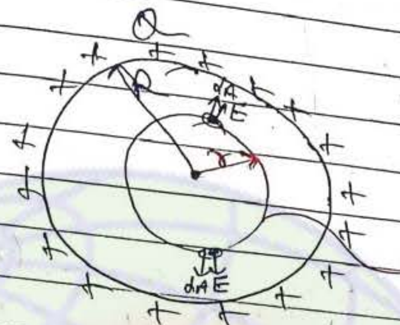
$$\cancel{\frac{Q}{\varepsilon_0} = E \times 4\pi r^2}$$

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

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

Case 2nd →

$r < R$



$$\phi = E\,dA + E\,dA + \ldots$$

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

$$\frac{q_{encl}}{\varepsilon_0} = E \times 4\pi r^2$$

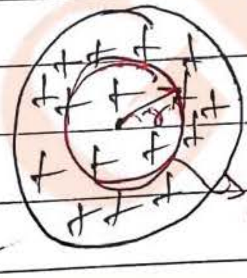
$$0 = E \times 4\pi r^2$$

$$\boxed{E = 0}$$

Note

If the sphere is not conducting formula of E for $r > R$ is same as that of solid conducting sphere

but for $r < R$ कहानी में Twist आ जाएगा ~~to~~ because charge enclosed will not be zero



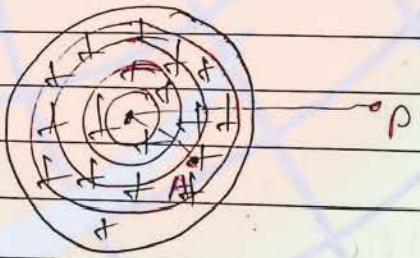
$$q_{enclosed} = \rho \times \frac{4}{3}\pi r^3$$

1st Choice

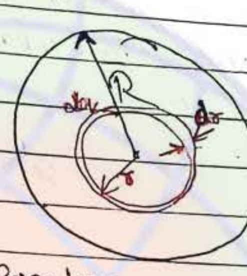
$$\rho \times \frac{4}{3}\pi r^3 = E \times 4\pi r^2$$

$$\boxed{E = \frac{\rho r}{3\varepsilon_0}}$$

* Solid non-conducting sphere is like is बंदा गोभी or प्याज as it ~~of~~ is made of large number of hollow sphere placed one one another.



(xii) A sphere of radius R have total charge Q is distributed within the volume of sphere with volume charge density ($\rho = ar$) where r is radial distance from centre of sphere.



Determine :-

i) value of a

ii) Determine E at $r = R$

iii) Determine E at $r = \frac{R}{2}$

Soln

नोट :- यहाँ ध्यान दें volume charge density (ρ) Radius के साथ change हो रहा है

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

ρ is changing with r

Now

$dq = \rho \times$ volume of element

$dq = ar \times 4\pi r^2 dr$

total charge $= Q = \int_0^R 4\pi a r^3 dr$

$$Q = \pi a R^4$$

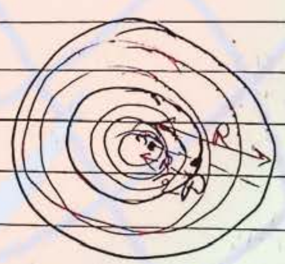
$$a = \frac{Q}{\pi R^4}$$

ii) $E = \frac{KQ}{R^2}$ (total charge Center)

Concept →
In radial non-uniform distribution of charge in solid sphere electric field and potential on the surface or outside the surface is given by the same formula as that in uniform distribution

$E = \frac{KQ}{r^2}$ $r \geq R$

iii)



$$E = \frac{K[\text{charge enclosed under } r \leq R/2]}{(R/2)^2}$$

$$\text{charge enclosed} = \int_0^{R/2} 4\pi a r^3 \, dr$$

$$= \frac{\pi a R^4}{2^4} = \frac{\pi a R^4}{16}$$

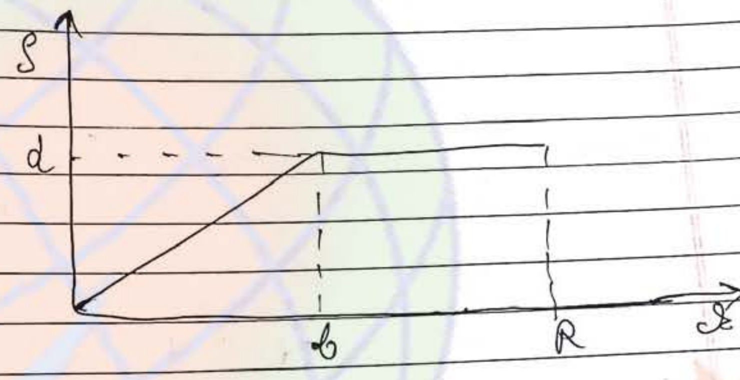
Putting value of a

$$\cancel{E = \frac{\pi}{16} \frac{Q}{\pi R^4} \times R^4}$$

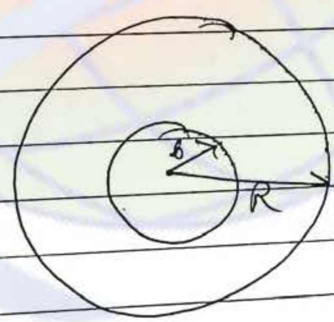
$$E = K \times \frac{\pi a R^4}{\cancel{16\varepsilon_0} R^2 \cdot 4}$$

$$E = \frac{KQ}{4R^2}$$

Q2.) Determine E at R



Sol^n



$$Q_{\text{enclosed}\ (r \le R)} = \int_0^b \rho \times 4\pi r^2\, dr + d \times \frac{4}{3}\pi \left[R^3 - b^3\right]$$

$$y = mx$$

$$\rho = \frac{d}{b} r$$

$$\int_0^b \frac{d}{b} r \times 4\pi r^2 \, dr + d \times \frac{4}{3}\pi \left[R^3 - b^3\right]$$

आगे का solve कर ही लेंगी

question
1st Choice

Question of 2006

Page No. 327
Date

11/2006

charge density (ρ)

solid Insulating sphere

Determine the electric field Intensity (E) at any point cavity.

Sol^n ① + ② ⇒ Complete sphere

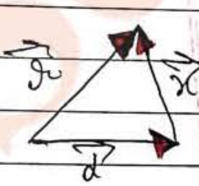
$$\vec{E_1} + \vec{E_2} = \vec{E}$$

$$\vec{E_1} + \frac{\rho\vec{x}}{3\varepsilon_0} = \frac{\rho\vec{r}}{3\varepsilon_0}$$

$$\vec{E_1} = \frac{\rho}{3\varepsilon_0}(\vec{r}-\vec{x})$$

very Imp

$$\boxed{\vec{E} = \frac{\rho\vec{d}}{3\varepsilon_0}}$$

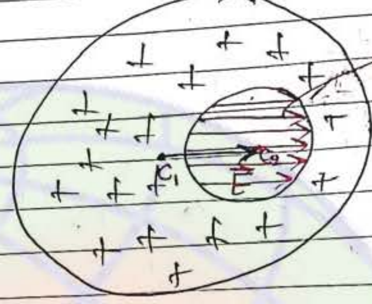


$$\vec{d} + \vec{x} = \vec{r}$$

$$\vec{d} = \vec{r} - \vec{x}$$

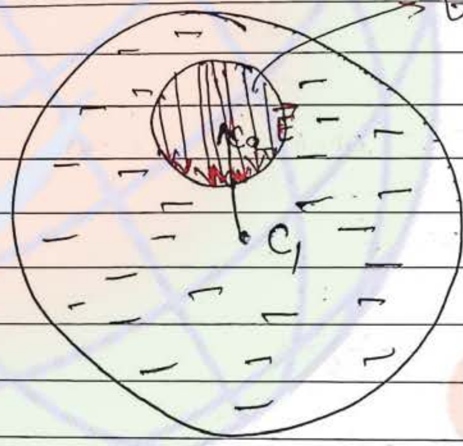
$$|\vec{d}| = d$$

Note:-> In this question direction of E is as follows (charge is +ve)



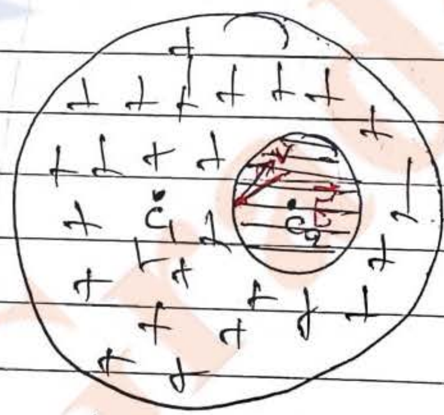
E is uniform.
(+ve charge रहने पर big sphere की centre से small sphere की centre की ओर)

Note:-> (If charge is -ve)



E is uniform.
(-ve charge रहने पर small sphere की centre से big sphere की centre तक)

Concept:->



Here if anyone tells ... gives

$d=0$
so $E=0$

Cnamma unifor "E" की भी आ सकती type की Problem भी पूछे सकता है जैसे ऊपर दिये projectile का question आ सकता है

जुगी क्या और centre है ... मा Centre ... पर है

Attention →

★ As electric field is uniform examiner can ask all type of question in uniform electric field that we have already done in electrostatic condition

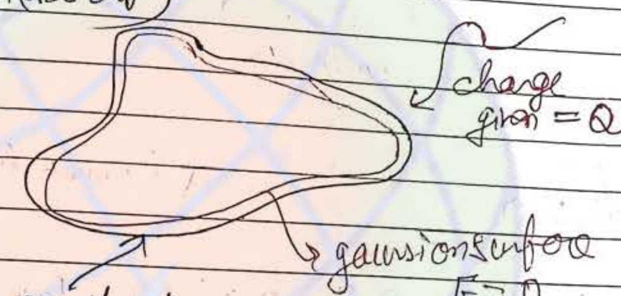
1st Choice

Page No. 33
Date / /

Conductor in "electrostatic equillibrium":

1) Electric field in the bulk of conductor is zero.
i.) charge given to conductor distribute itself over the surface of conductor in such a way that Electric field in the bulk of conductor become zero.

Proof → in (Board)



$E = 0$
$\phi = 0$
$q_{en} = 0$

No charge in the bulk of conductor.

So, All charge is present on the surface of Conductor.

(No charge in bulk of conductor)

2) Electric field Intensity near the surface of conductor is always Normal to surface and it's magnitude is given by the formula

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

where
σ = surface charge density

(यदि Normal नहीं होता तो E का कोई component आता जिससे "e-static condition" follow नहीं हो पाता।

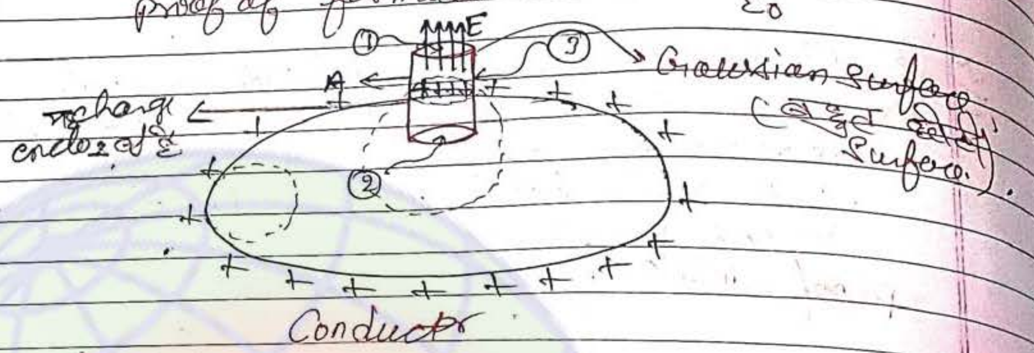
1st Choice

Page No. 892

~~Proof~~ (for 3 marks)

Proof ⇒

proof of formula $E = \frac{\sigma}{\varepsilon_0}$



$\phi_2 = 0$ $\{ E = 0$ (Conductor के अंदर है)

$\phi_3 = 0$ $\{$ $E = 0$ for certain portion (अंदर)
$E \perp A$ for certain portion (बाहर)

$\phi_1 = EA$

$\phi_{total} = EA$

$\frac{q_{enc}}{\varepsilon_0} = EA$ $\therefore$ $\sigma = \frac{Q}{A}$
$(Q = \sigma A)$

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

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

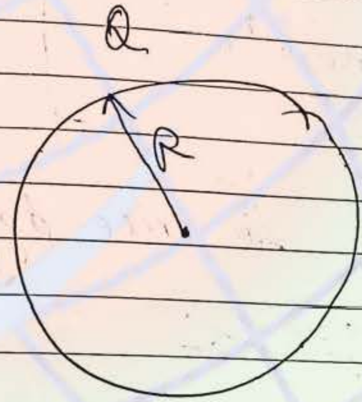
3. Any surface can be assumed as a part of the sphere. Therefore E near the conductor surface of any shape is given by

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

and V is given by

$$\boxed{V = \frac{\sigma R}{\varepsilon_0}}$$

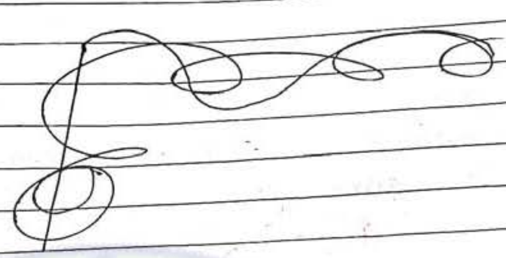
where R is radius of curvature of sphere.



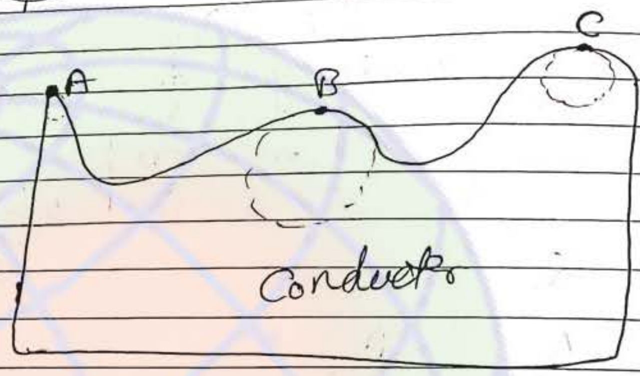
$$\boxed{E = \frac{Q}{4\pi\varepsilon_0 R^2} = \frac{\sigma}{\varepsilon_0}}$$

$$V = \frac{Q}{4\pi\varepsilon_0 R} \times \frac{R}{R}$$

$$V = \frac{\sigma R}{\varepsilon_0}$$



Q1.



Arrange following in ascending order.

(A) $\sigma_A, \sigma_B, \sigma_C$

(B) E_A, E_B, E_C

(C) V_A, V_B, V_C.

Sol^n At electrostatic condition metal is equipotential

$$\frac{\sigma R}{\varepsilon_0} = \text{Constant}.$$

$$\boxed{\sigma R = \text{Constant}}$$

$$\boxed{\sigma \propto \frac{1}{R}}$$

याद रखें
In case of conductor Radius of curvature (conductor की सतह) is inversely proportion to "σ" of the conductor

1st Choice

so,

$R_A < R_C < R_B$

a) $\sigma_A > \sigma_C > \sigma_C$

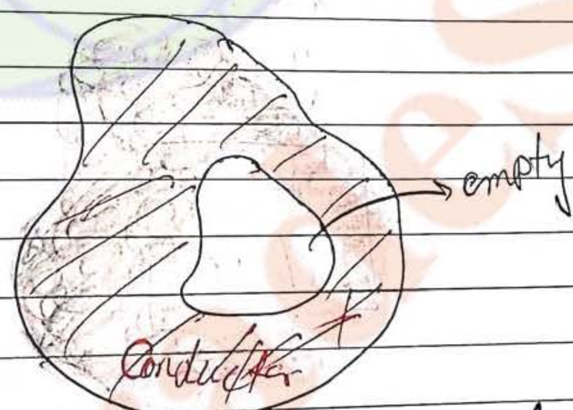
b) $E_A > E_C > E_B$ $\left(\because E = \frac{\sigma}{\varepsilon_0}\right)$

(c) $V_A = V_B = V_C$

(याद रखें)
Concept → जितना sharp होगा σ उतना अधिक होगा।

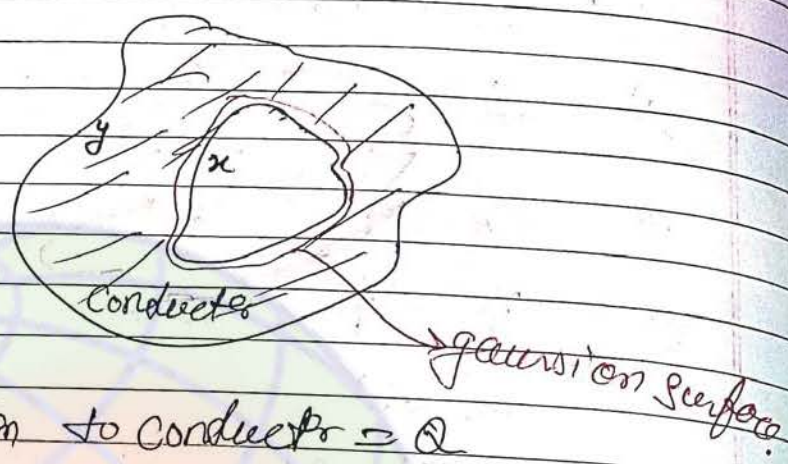
"σ is high at sharp corner of conductor"
इसका मतलब समझिये कि किसी भी conductor के sharp point पर Area charge density (σ) अधिक होता है।

4) If a conductor ~~have~~ has cavity which is empty then



Then,
charge given to such conductor will residue only on outer surface of conductor not in ~~IN~~ Inner surface of cavity.

Proof :→



charge given to conductor = Q

$$x + y = Q$$

$$\oint_{\substack{\text{gaussian}\\ \text{surface}}} = \frac{x}{\varepsilon_0}$$

$$0 = \frac{x}{\varepsilon_0}$$

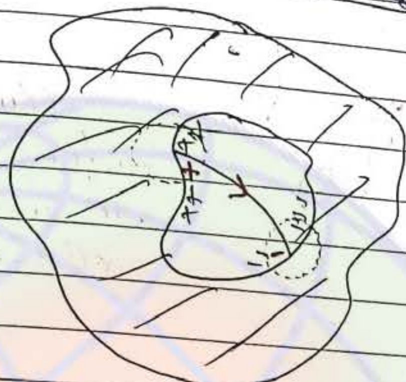
$$x = 0$$

$$y = Q$$

$$\boxed{\begin{matrix} E = 0 \\ \phi = 0 \end{matrix}}$$

(6) Electric field Intensity in empty cavity is always Zero

Proof ⇒ ~~$V_A \; V_B$~~



Let, such E.L.F is possible because It does not violate gauss law as net charge Inside cavity is zero, लेकिन

As conductor is equipotential "$V_A = V_B$" (V_A should be equal to V_B) however we can see here If we go In the direction of E.L.F or E potential decreases i.e.

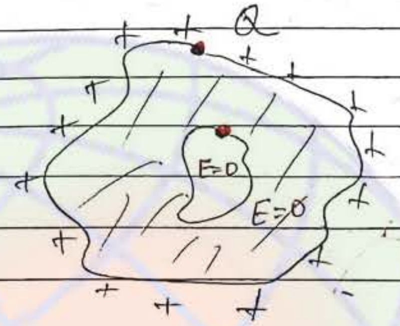
$V_A > V_B$.

Therefore such type of E.L.F is not possible

> इसमें बैठोगे तो safe हो। (यहाँ) इसका उपयोग होता है इसलिए इसमें safe होगे। बिजली गिरने पर effect नहीं करेगा।

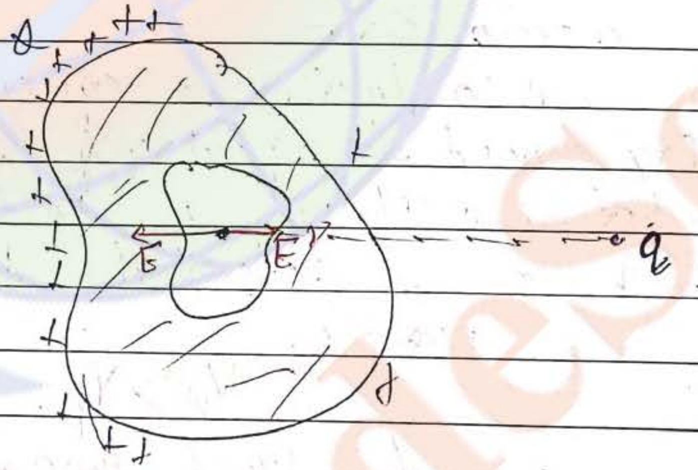
Electrostatic Shielding (defensive Concept)

(i) If empty cavity conductor is present in external electric field then also E.F. inside cavity is zero



E due to charge on outer surface of conductor inside conductor outer surface as well as on cavity = 0.

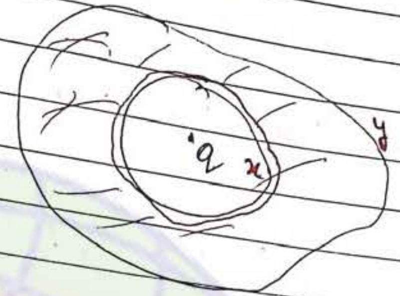
7) when this conductor is in electric field of charge "q"



$\vec{E}_{\text{due to charge } q} + \vec{E}_{\text{due to charge on outer surface of conductor}} = 0$

(ext. E field) — inside cavity and bulk of conductor

8) If cavity is not empty, then there will be charge on inner surface of cavity.



$x+y=0$

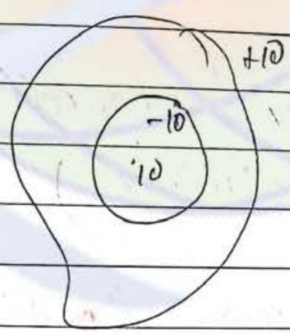
charge on conductor $=0$

$E=0 \therefore \phi=0$

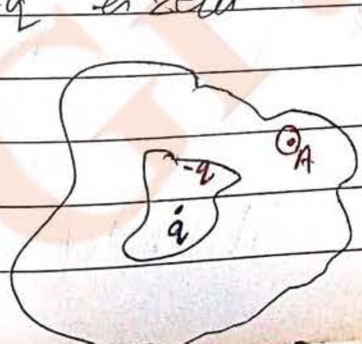
$\frac{q+x}{\varepsilon_0}=0$

$x=-q$
$y=q$

Eg.



9.) (8) Electric field Intensity and electric potential outside the cavity due to charge "q" and induced charge $-q$ is zero



None.

At Pos at A

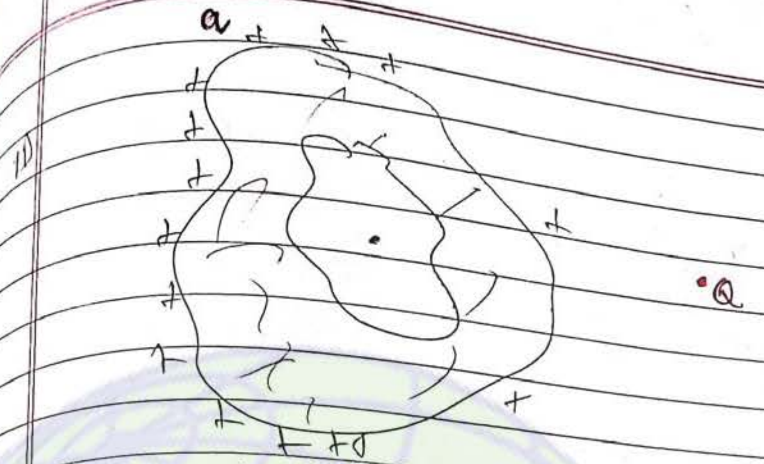
$\vec{E}_{due\ to\ q} + \vec{E}_{due\ to\ -q} = 0$

$V_{due\ to\ q} + V_{due\ to\ -q} = 0$

10.) At point "P" or A net electric field and potential is due to the charge present on outer surface only.

"-q" जो है वह "q" के E एवं V को cancell करने के लिए जन्म लेता है (cavity के बाहर)

If we displace small "q" charge inside cavity distribution of charge "-q" get change.



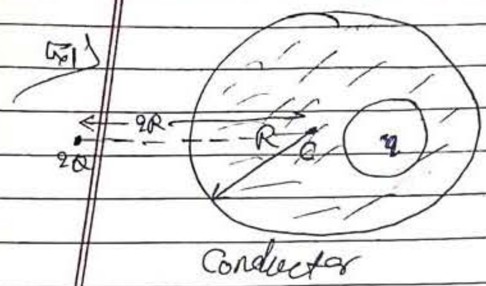
If we displace Q change distribution of charge on outer surface get change because outer surface charge has to cancel E of charge Q

outer surface and outer surface के बाहर वाले charge का combined effect outer surface के लिए zero होता है।

cavity के अंदर and at cavity surface वाले charge का effect E and V cavity के बाहर zero होता है।

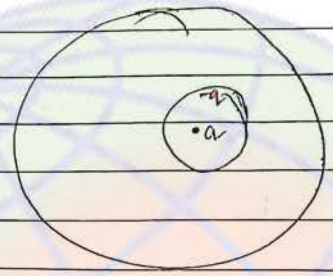
(4) cavity divides the entire world into two parts

Q.1)



Determine force on "q".

So/



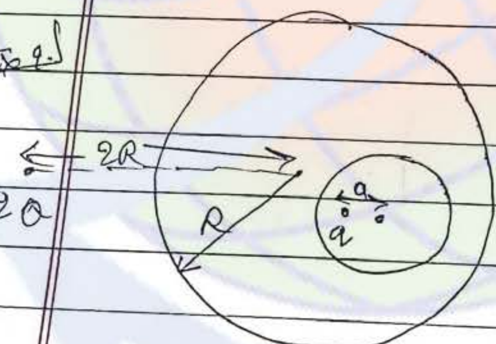
Force that can act on "q" is only by the Induced charge "-q" Inside cavity

but E due to "-q" at centre of cavity is Zero

$\boxed{F = 0}$

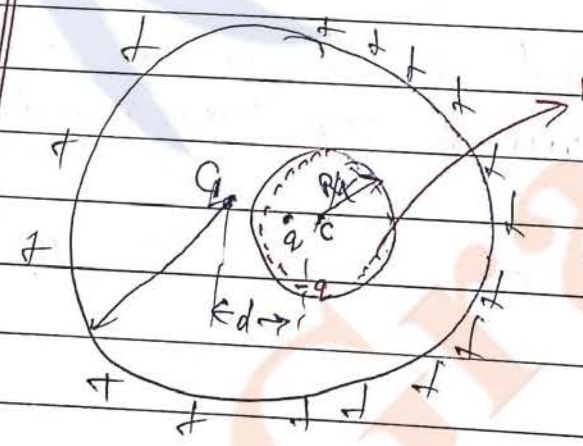
Therefore force on small "q" is zero.

Q.2)



Determine force on small "q".

So/



non-uniform distribution.

because of non-uniform distribution we can not determine E due to "-q" sphere at the location of "q". Therefore

And we can't determined

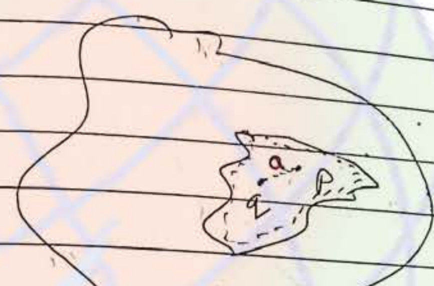
Determine potential at centre of cavity

$$V_c = \frac{kq}{a} + \frac{-kq\times 4}{R} + \frac{k2Q}{2R+d} + \text{नहीं निकाल सकते हैं}$$

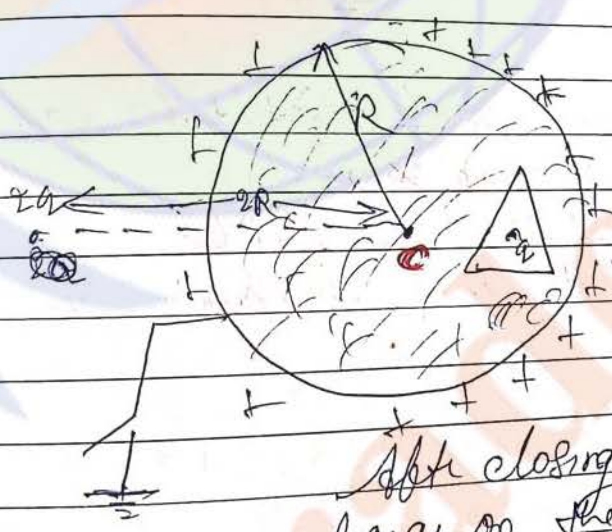
[V due to charge on outer surface]

(V_c can't be determined)

Note !->

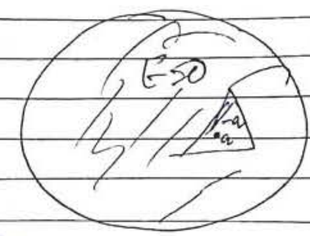


Ex2



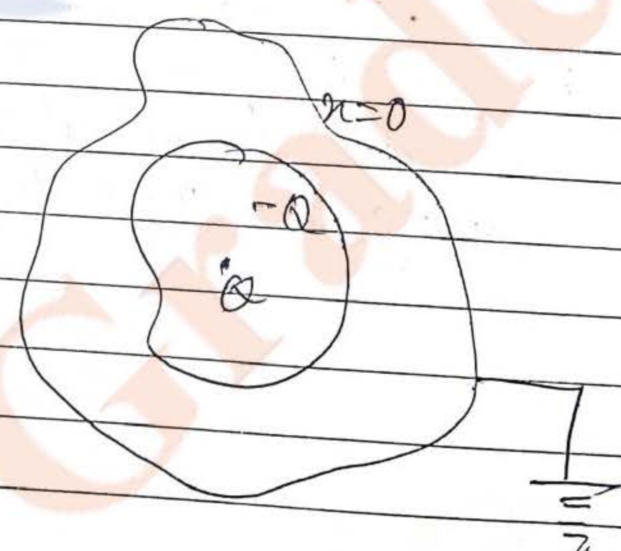
before closing of switch, conductor of neutral.

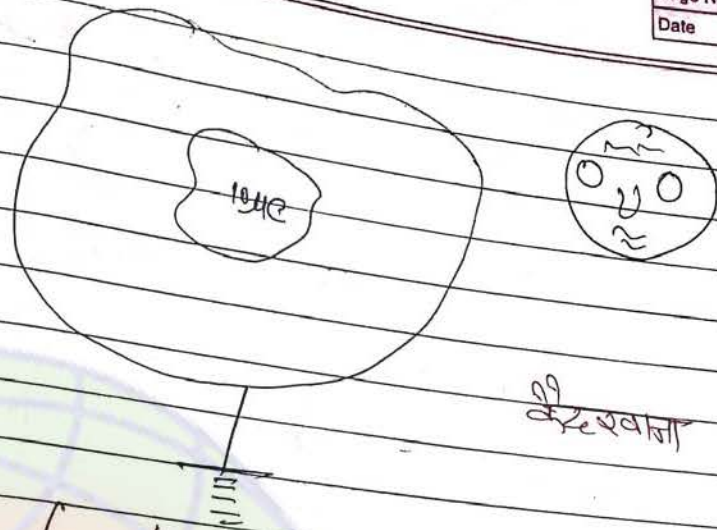
After closing of switch determine charge on the outer surface of conductor



$$V_C = \frac{kq_a}{2R} + \frac{kx}{R} = 0$$

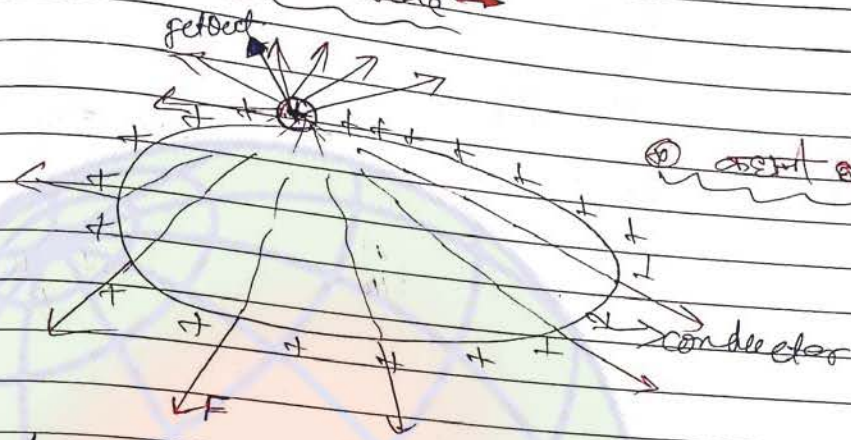
After closing of switch potential of conductor of potential become zero. and this is possible only charge on outsurface that is x becomes zero.





(Electrostate blocker)

Electrostatic Pressure →

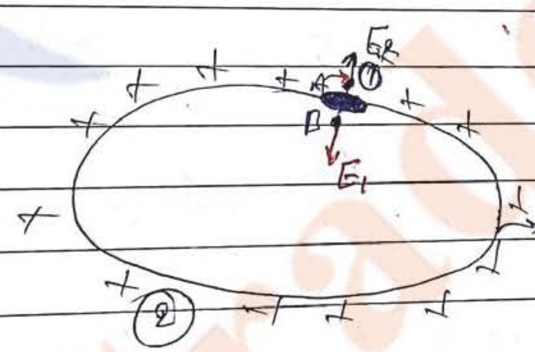


when charge is given to conductor electrostatic repulsive force act b/w the charges on the metal surface

due to this repulsive force outward, normal electrostatic pressure act on the surface and it's magnitude is

$$\boxed{P = \frac{\sigma^2}{2\varepsilon_0}}$$

Proof:-



(at A, E should be zero)

$E_1 - E_2 = 0$

Area of $\triangle = dA$

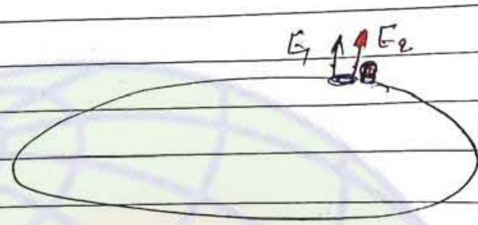
charge of Area ① $= \sigma dA$

$E_2 \Rightarrow$ E due to (2) at the location one "1"

$$F = q E_2 = \sigma\, dA \times E_2$$

$$P = \frac{F}{dA} = \sigma E_2$$

(1) ⇒ Point charge (बहुत छोटा है)



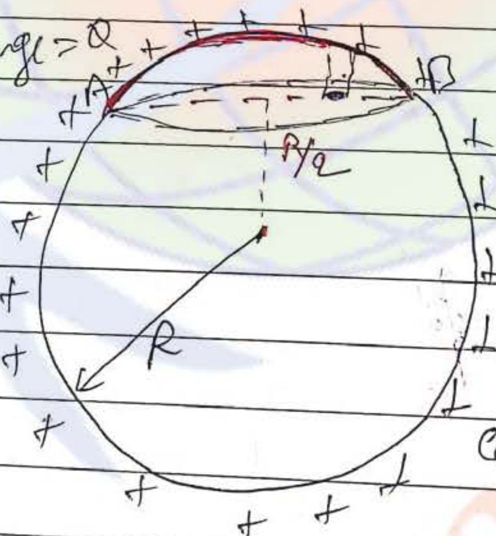
At B, E should be "$\frac{\sigma}{\varepsilon_0}$"

$$E_1 + E_2 = \frac{\sigma}{\varepsilon_0}$$

$$E_2 = \frac{\sigma}{2\varepsilon_0}$$

$$\boxed{P = \frac{\sigma^2}{2\varepsilon_0}}$$

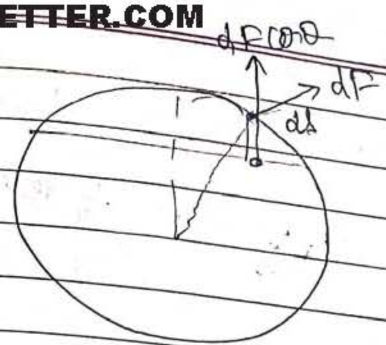
Q. charge = Q



force on portion AB of sphere

conducting sphere

⇒ Calculate the force on AB portion of sphere.



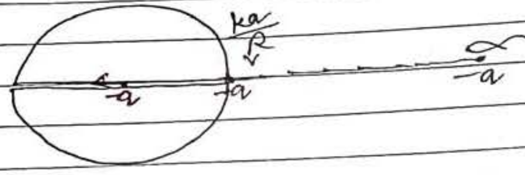
$$dF = \frac{\sigma^2}{2\varepsilon_0} ds$$

$$\frac{\sigma^2}{2\varepsilon_0} ds \cos\theta$$

$$\boxed{F = \frac{\sigma^2}{2\varepsilon_0} \times \text{Projected Area} = \frac{\sigma^2}{2\varepsilon_0}\left[\pi r^2\right]}$$

Ex-3

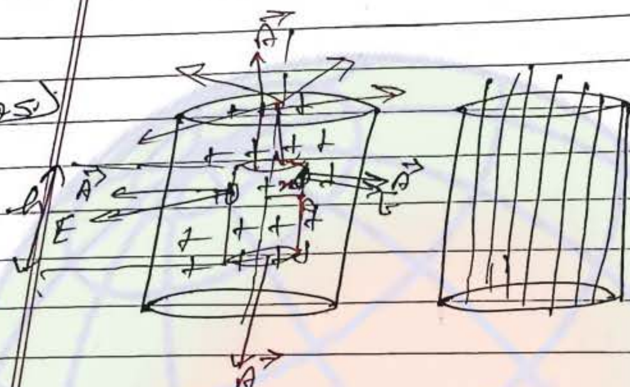
Q1.)



$\frac{1}{2}mv^2 + \frac{kQ}{R}(-a) = 0$

$\frac{1}{2}mv_1^2 + \frac{3}{2}\frac{kQ}{R}(-a) = 0$

Q5.)



$\phi = EdA + EdA + \ldots$

$= E(dA + dA + \ldots)$

$= E \times 2\pi x h$

$\frac{q_{in}}{\varepsilon_0} = E \times 2\pi x h$

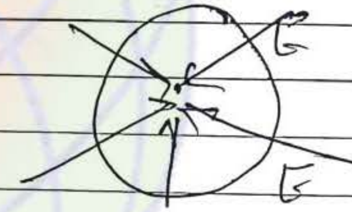
$\rho \pi x^2 h = E \times 2\pi x h$

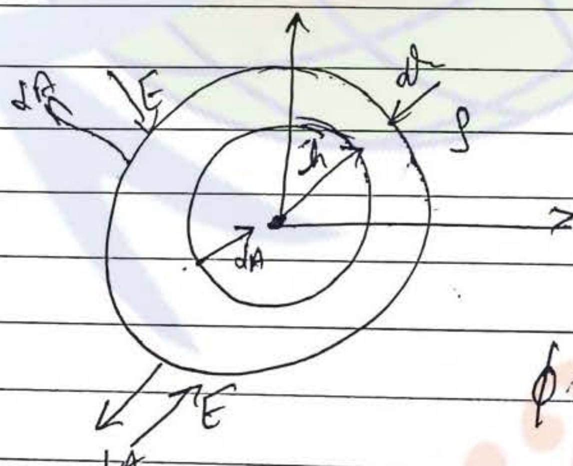
Q9.)

$V = ar^2 + b$

$\vec{E} = -\frac{dV}{dr}\hat{r}$

$\vec{E} = -2ar\hat{r}$





$\phi_{enclosed} = \frac{q_{en}}{\varepsilon_0}$

$\phi_{enclosed} = \frac{4\pi r^2 dr \rho}{\varepsilon_0}$

$\phi_2 = -EdA - EdA + \ldots$

$= -2a(r + dr)\, 4\pi(r + dr)^2$

$\phi_1 = EdA + \ldots\ldots + EdA$

$= 2ar \times 4\pi r^2$

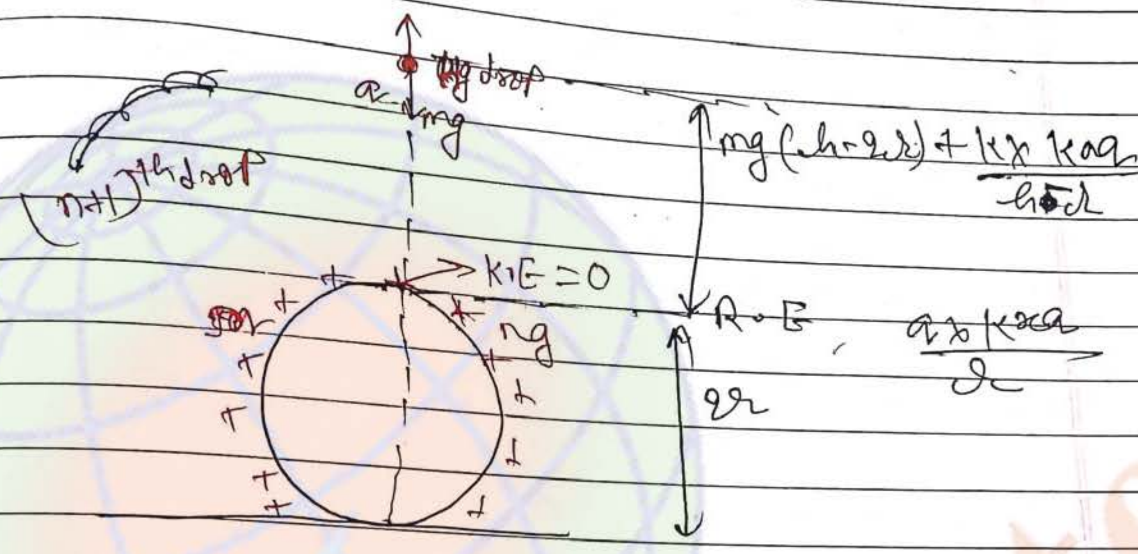
$= 8\pi ar^3$

$$\phi = 8\pi a r^2 \left[1 - \left(1 + \frac{dr}{r}\right)^3\right]$$

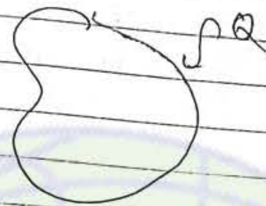
$$= 8\pi a r^3 \left[-\frac{3dr}{r}\right]$$

$$= -24\pi a r^2 dr$$

12)



(A) capacitor of conducter :- (cc)



$E \propto Q$

$V = -\int E \cdot dr$

$V \propto E$

$V \propto Q$

$V = Q \times \frac{1}{C}$

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

C = capacitance

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

capacitance of a conducter is defined as amount of charge on conducter to potential of that conductr

or

Amount of charge required to increase the potential of conducter by one volt is known as capacitance.

$q = 1$ volt

$Q = C$

(8) unit of capacitance is "Farad."

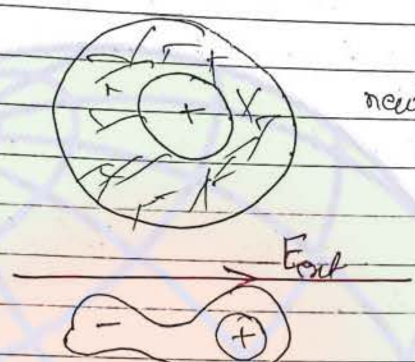
1 Farad is a very big unit. Therefore in Questions we will normally see micro farad (μF) or Pico farad (PF)

Note→

Capacitance is also define the ability to store max. possible charge without lickage or licking.

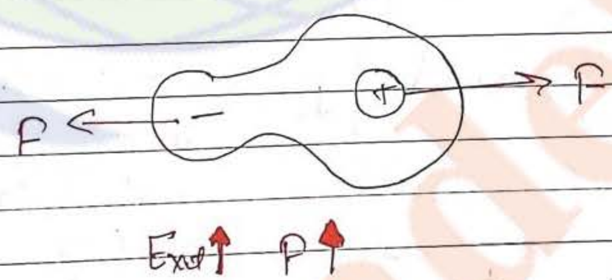
Insulator (कुचालक)

☆ Di-electric breakdown → (Ionisation of medium →



1) On application of External electric field seperation of charge take place and neutral atom become electric dipole.
This process is known as polarisation.

2) If Eext is very high than Ionisation of neutral atom can take place.

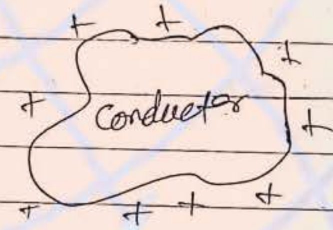


Ionisation
Breakdown of dielectric (Insulator)

3) External electric field in which Insulator or dielectric get breakdown or Ionize is known as di-electric strain of that medium

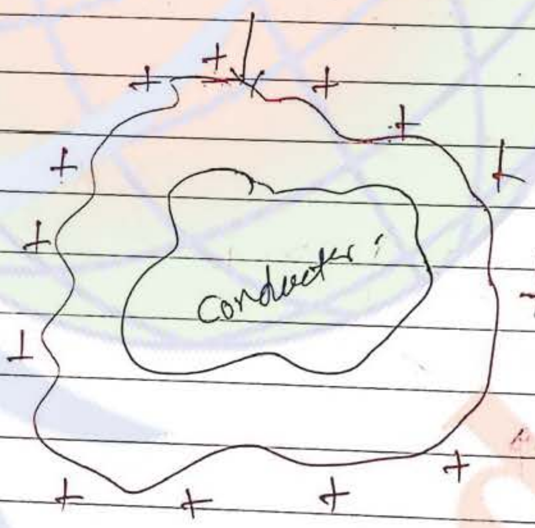
After breakdown dielectric or Insulator become conductor.

di-electric Strength 3×10^6 V/m



Q↑ E↑

ज्यादा Q ज्यादा E ⇒ dielectric strength

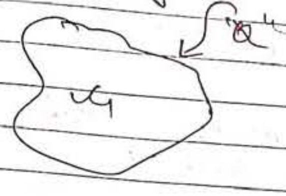


Then nearly medium become conductor and charge starts leaking out of Conductor.

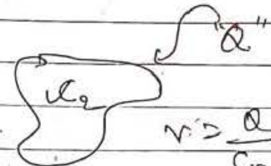
159 | Ex-3 → Complete

5.) what effect we observed when same charge (Q) given to two diffⁿ body having capacitance C_1 and C_2, where $C_1 > C_2$?

when $\boxed{C_1 > C_2}$



$V = \frac{Q}{C_1}$



$V = \frac{Q}{C_2}$

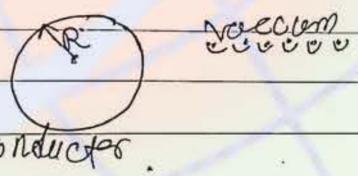
For same charge ∴ V is high for C_2

∴ E is high for C_2

∴ Breakdown occur's fast at C_2.

☆ Questions of capacitance →

Eg.)



Conductor.

Determine it's capacitance

Step 1st → Give charge Q

Step 2nd → Determine "V" at surface

$$\boxed{V = \frac{Q}{4\pi\varepsilon_0 R}} \quad [\because C_{air} = 4\pi\varepsilon_0 R]$$

Step 3rd →

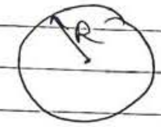
$$C = \frac{Q}{V}$$

→ "C" is depend on size (R)

Note → धारिता of sphere

$$\boxed{C_{air} = 4\pi\varepsilon_0 R}$$

Eg. Determine it's capacitance



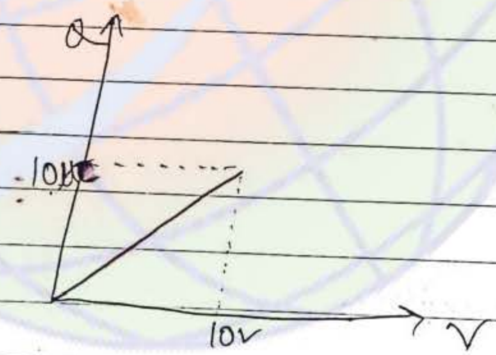
medium of di-electric constant "k"

$$V = \frac{Q}{4\pi\varepsilon_0 R}$$

$$\boxed{C_{med} = 4\pi\varepsilon_0 R \times K}$$

* Capacitance depend on surrounding medium.

[Ex3.]



Determine cap. of the conductor if Q versus V graph is given.

Sol^n

$$\text{slope} = \frac{Q}{V}$$

$$Q = CV$$

$$\text{slope} = C$$

$$C = \frac{10 \times 10^{-6}}{10}$$

$= 10^{-6}$

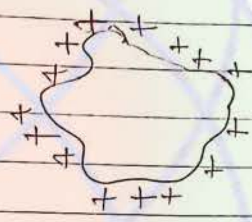
$= 1\mu F$

so,

$C = 1\mu F$

Note →

If we know capacitance of the conductor of any shape than we can determine charge on it If potential is known and vice-versa.



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

than find 'C'

Energy of Conductor (Self energy)

I) When we charge the conductor work has to be done against electric field of charge of conductor to bring all the charges together on the surface of conductor.

II) This workdone is stored as the potential energy of conductor known as "self energy of conductor".

III) Self energy of conductor is equal's to

$$\boxed{\text{self energy} \Rightarrow \frac{Q^2}{2C} \text{ or } \frac{QV}{2} \text{ or } \frac{1}{2}CV^2}$$

This formula is valid only for conductor

$Q \rightarrow$ charge on conductor
$V \rightarrow$ Potential of conductor due to charge Q.
$C \rightarrow$ capacitance of the conductor.

IV) This self energy is stored in the electric field of conductor,

V) Self energy is distributed with energy density

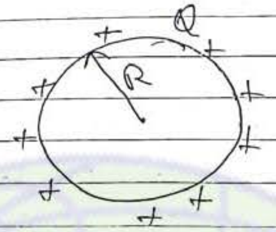
$$\boxed{\underset{\text{(energy density)}}{U_d} = \underset{\text{(in vaccum)}}{\frac{1}{2}\varepsilon_0 E^2} \text{ and } \underset{\text{(in medium of di-electric constant}=K)}{\frac{1}{2}K\varepsilon_0 E^2}}$$

energy density → Energy per unit volume

This formula is valid for both conductor and Insulator.

Question's of energy →

Ex.)



Determine energy of System.

Sol^n

$$P.E = \frac{Q^2}{2C}$$

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

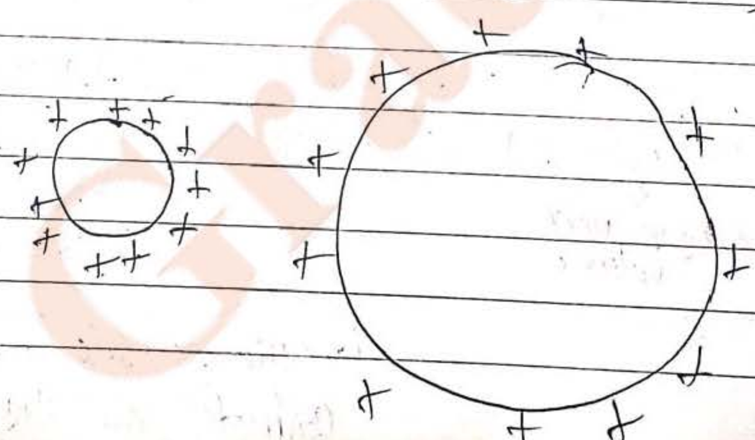
$$= \frac{Q^2}{8\pi\varepsilon_0 R}$$

Ex2.) In the previous question determine the workdone by electric field. In expanding radius of sphere from R to 4R

Sol^n

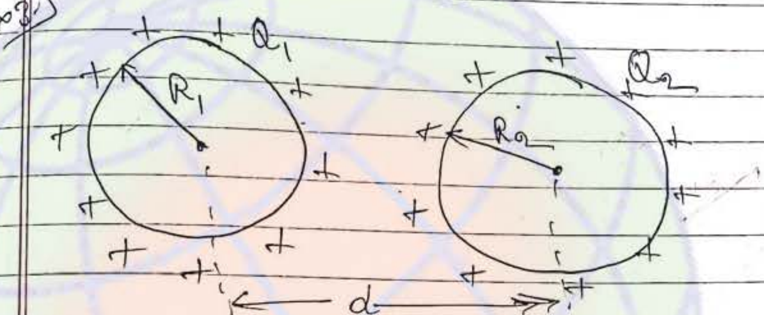
$$W = -(P.E_f - P.E_i)$$

$$= -\left(\frac{Q^2}{8\pi\varepsilon_0(4R)} - \frac{Q^2}{8\pi\varepsilon_0 R}\right)$$



Conclusion:-
whenever distribution of charge on the conductor surface change we have to also think about self energy of conductor because that will also change.

Ex 3)



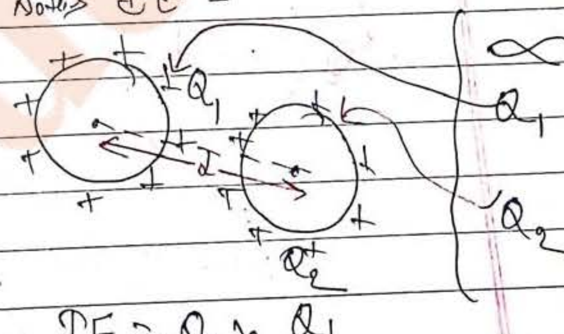
(do not consider Induction effect)

Determine total energy of system

Soln P.E ⇒ self energy of ① + self energy of ② + Interaction energy.

$$= \frac{Q_1^2}{8\pi\varepsilon_0 R_1} + \frac{Q_2^2}{8\pi\varepsilon_0 R_2} + I.E$$

Note:> IE =

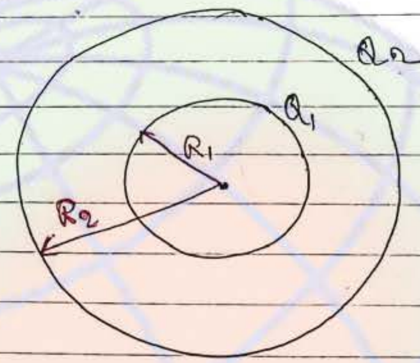


$$IE = Q_2 \times \frac{Q_1}{4\pi\varepsilon_0 d}$$

Sol.

$$P.E = \frac{Q_1^2}{8\pi\varepsilon R_1} + \frac{Q_2^2}{8\pi\varepsilon_0 R_2} + Q_2 \times \frac{Q_1}{4\pi\varepsilon_0 R_2}$$

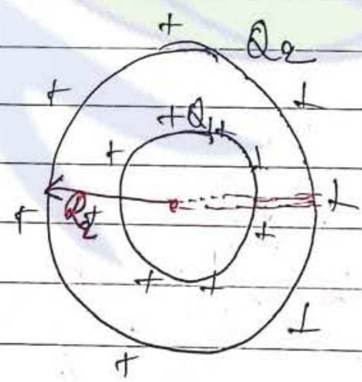
4.)



Determine P.E. of system

Sol/n P.E = Self energy of (1) + Self energy of (2) + I.E

$$= \frac{Q_1^2}{8\pi\varepsilon R_1} + \frac{Q_2^2}{8\pi\varepsilon_0 R_2} + I.E \quad \text{—(i)}$$

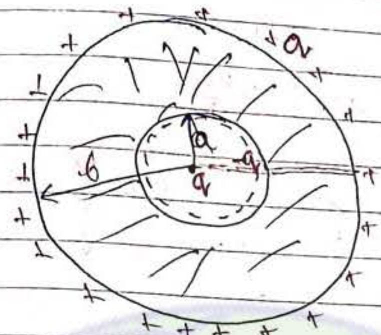


$$I.E = \frac{Q_1 \times Q_2}{4\pi\varepsilon R_2} \quad \text{—(ii)}$$

From eq (i) & (ii)

$$P.E = \frac{Q_1^2}{8\pi\varepsilon_0 R_1} + \frac{Q_2^2}{8\pi\varepsilon_0 R_2} + \frac{Q_1 \times Q_2}{4\pi\varepsilon_0 R_2}$$

Brodore



shell is neutral ~

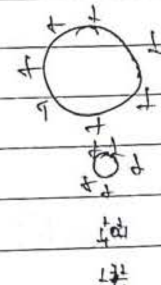
$\left\{ \begin{matrix} \infty \\ q \end{matrix} \right.$

Determine the workdone in shifting charge "q" from centre to "∞"

Sol^n.

$$\text{W. done} = (P.E_f - P.E_i)$$

Point charge का self energy → ∞ होता है because $R \to 0$

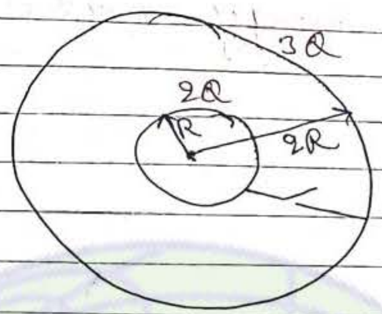


self energy of point charge is "∞" but it's never changes because point charge does not change it's shape. (फिर लगाया नहीं लगेगा) Therefore there is not need to define S.E (self energy) for point charge

$$P.E_i \rightarrow \text{selfenergy of } q + \text{selfenergy of } q + \underbrace{IE}_{\text{(Interaction energy)}}$$

$$= \frac{q^2}{8\pi\varepsilon_0 a} + \frac{q^2}{8\pi\varepsilon_0 b} + IE \qquad \text{—(i)}$$

Ex 6)

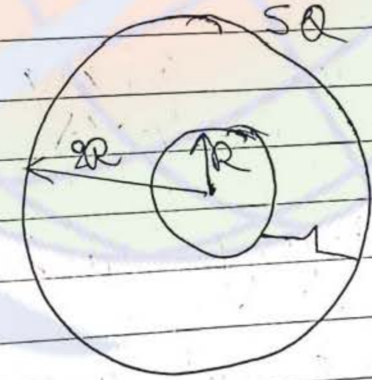


Determine ratio of T.E of system before closing switch and after closing the switch.

Sol^n

$$P.E_i = \frac{(2Q)^2}{8\pi\varepsilon_0 R} + \frac{(3Q)^2}{8\pi\varepsilon_0 (2R)} + \frac{3Q + 2Q}{4\pi\varepsilon_0 (2R)}$$

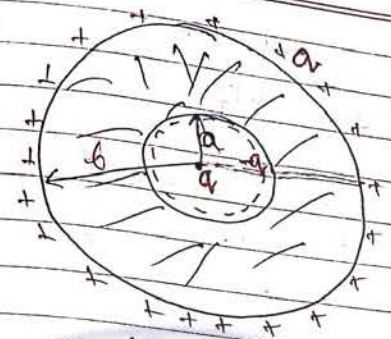
After closing of switch



$$P.E_f = \frac{(5Q)^2}{8\pi\varepsilon_0 (2R)} + 0$$

(P.E = 0)

Before (GOOD)



shell is neutral

$\int_q^{\infty}$

Determine the workdone in shifting charge "q" from centre to "∞"

Sol^n W. done $= (P.E_f - P.E_i)$

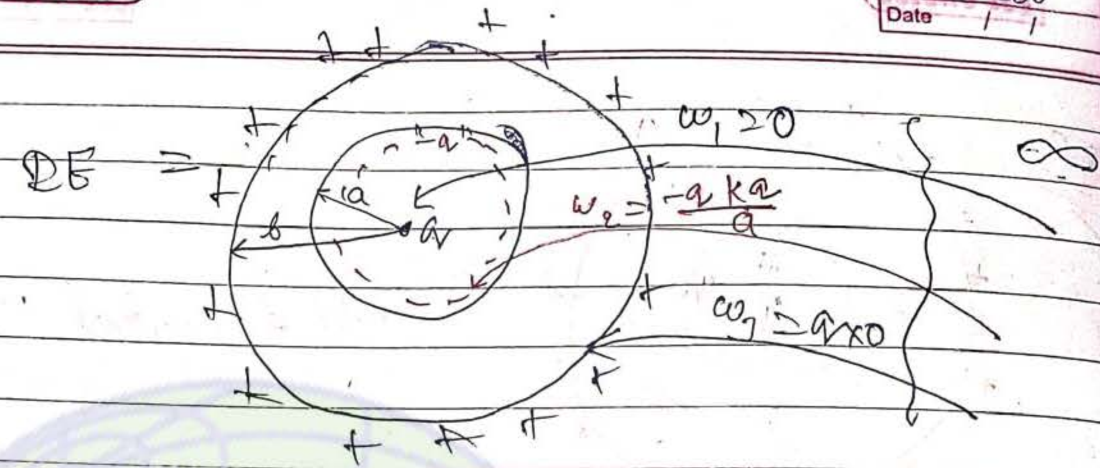
Point charge का self energy $\to \infty$ होता है because $R \to 0$

Self energy of point charge is "∞" but it's never changes because point charge does not change it's shape. (कभी टूटेगा नहीं फैलेगा)

Therefore there is not need to define S.E (self energy) for point charge

$P.E_i \to$ self energy of q + self energy of q + IE (Interaction energy)

$$= \frac{q^2}{8\pi\epsilon_0 a} + \frac{q^2}{8\pi\epsilon_0 b} + IE \quad \text{---(i)}$$



$$PE = \frac{-kq^2}{a}$$

$$= \frac{-q^2}{4\pi\varepsilon_0 a}$$

$$P.E_i = \frac{q^2}{8\pi\varepsilon_0 a} + \frac{q^2}{8\pi\varepsilon_0 b} - \frac{q^2}{4\pi\varepsilon_0 a}$$

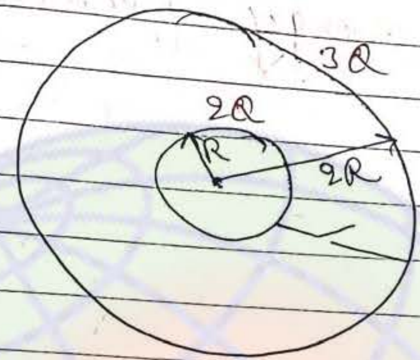
$$P.E_i = \frac{q^2}{8\pi\varepsilon_0}\left[\frac{1}{b} - \frac{1}{a}\right]$$

$$P.E_f = 0$$

$$W = P.E_f - P.E_i$$

$$= -P.E_i$$

Ex 6

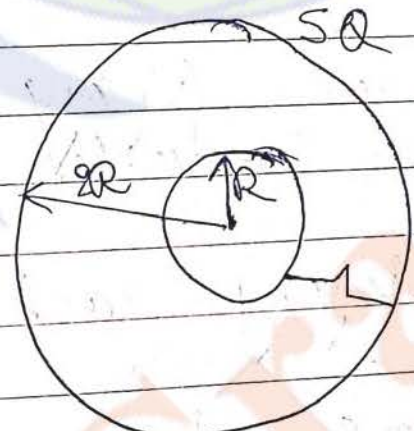


Determine ratio of T.E of system before closing switch and after closing the switch.

Sol

$$P.E_i = \frac{(2Q)^2}{8\pi\varepsilon_0 R} + \frac{(3Q)^2}{8\pi\varepsilon_0(2R)} + \frac{3Q \times 2Q}{4\pi\varepsilon_0(2R)}$$

After closing of switch



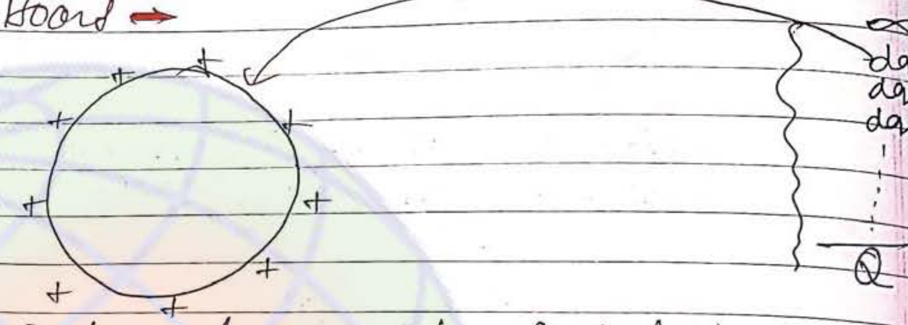
$$P.E_f = \frac{(5Q)^2}{8\pi\varepsilon_0(2R)} + 0$$

(P.E = 0)

~~For Board~~

Proof of Self energy formula →

For Board →



Conductor of capacitance (C) having charge Q

~~Let~~
~~we are assumed we bring~~

Let

→ Assuming we are bringing dq charge one by one on the Conductor.

→ Workdone in bringing each "dq" is different

→ ~~Also~~ Let assume at a certain Instant charge q has accumulated over conductor

→ At this Instant Potential on conductor is $= \frac{q}{C}$

→ work done in bringing dq charge on conductor at this Instant is $=$ "dq × Potential of conductor"

$= dq \times \frac{q}{C}$

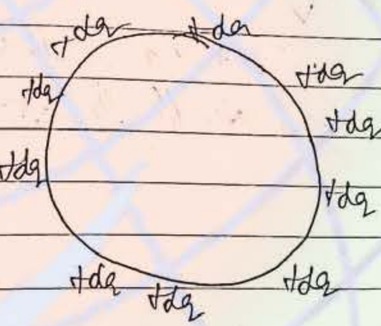
so

$$dw = \frac{q}{c} dq$$

$$W = \int_0^Q \frac{q}{c} dq$$

$$\boxed{P.E = W = \frac{Q^2}{2C} \text{ or } \frac{QV}{2} \text{ or } \frac{1}{2}CV^2}$$

IIT Alternate:-



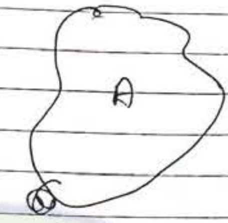
potential energy on conductor is "V"

$$P.E = \frac{(dq\,V + dq\,V + dq\,V + dq\,V + \ldots)}{2}$$

$$= \frac{V(dq + dq + dq + \ldots)}{2}$$

$$= \frac{QV}{2} \quad \text{Proved}$$

Q.



If we place neutral conductor near to conductor A then what effect will occur on capacitance of conductor A?

Sol

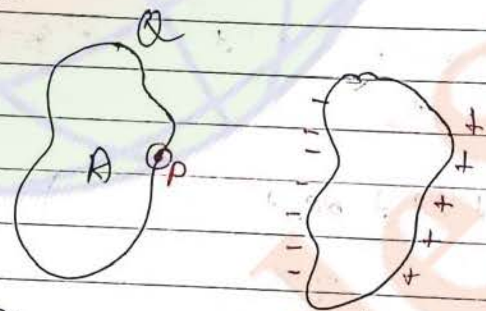
$C = \frac{Q}{V}$

V = potential of the conductor

V → actually due to Q

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

Now



Assume it's C is gone then it's potential

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

$V_{at\,P}$ after bringing conductor near by

$$V_{at\,P} = V + \underbrace{V_{due\,to\,\text{"}-\text{"}} + V_{due\,to\,\text{"}+\text{"}}}_{\text{Induced charge}}$$

Potential of conductor

$V_{due\,to\,\text{"}-\text{"}}$ is more than $V_{due\,to\,\text{"}+\text{"}}$

$$\therefore V_{due\,to\,P} = V + (-ve\ term)$$

$$V_{at\,P} < V$$

$$V_{at\,P} = \frac{Q}{C_{new}}$$

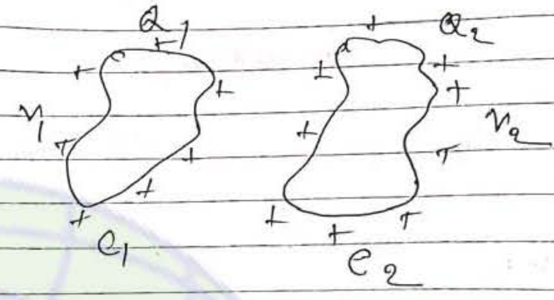
$$(\because C_{new} > C)$$

$$\boxed{\frac{Q}{C_{new}} < \frac{Q}{C}}$$

Good Idea →

capacitance of a conductor is Increase when a neutral conductor is Placed near by it.

Re-distribution of charge b/w conductor's →



$$\boxed{P.E = \frac{Q_1^2}{2C_1} + \frac{Q_2^2}{2C_2}}$$ → Include self + P.E

whenever two conductor are placed near by and the capacitance are given than their capacitance has already consider the effect of near by conductor.
and

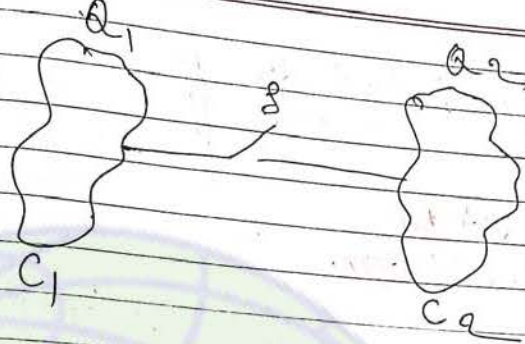
Alternate: —

$$P.E = \frac{dq\,V_1 + dq\,V_1 + \cdots + dq\,V_2 + dq\,V_2 + \cdots}{2}$$

$$P.E \Rightarrow \frac{Q_1 V_1}{2} + \frac{Q_2 V_2}{2}$$

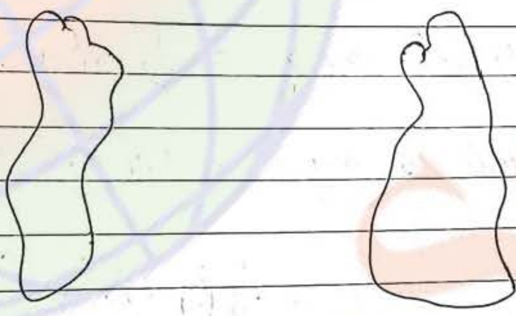
$$P.E \Rightarrow \frac{Q_1 \times Q_1}{2C_1} + \frac{Q_2}{2} \times \frac{Q_2}{C_2}$$

$$P.E = \frac{Q_1^2}{2C_1} + \frac{Q_2^2}{2C_2}$$



On closing of switch Re-distribution of charge take place b/w conducter's till potential of both conducter becomes on same and ~~that~~ this potential is know as common potential

Positive Q.



Initial Potential $\rightarrow$ $V_1 = \frac{Q_1}{C_1}$ $\qquad$ $V_2 = \frac{Q_2}{C_2}$

final potential $\rightarrow$ V $\qquad$ V

final charge $\rightarrow$ C_1V $\qquad$ C_2V

Conservation of charge

$$Q_1 + Q_2 = C_1V + Q_2V$$

So,

$$\boxed{V = \frac{Q_1 + Q_2}{C_1 + C_2}}$$

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

Common Potential

Q_1, Q_2 with sign.

(Q_1') Final charge on $C_1 = C_1 V = C_1\left[\frac{Q_1 + Q_2}{C_1 + C_2}\right]$

(Q_2') final charge on $C_2 = C_2 V = C_2\left[\frac{Q_1 + Q_2}{C_1 + C_2}\right]$

Ratio of final charges $\Rightarrow \frac{Q_1'}{Q_2'} = \frac{C_1}{C_2}$

$\Rightarrow$ Initial energy $= \frac{1}{2}C_1 V_1^2 + \frac{1}{2}C_2 V_2^2$

$\Rightarrow$ Final energy $= \frac{1}{2}C_1 V^2 + \frac{1}{2}C_2 V^2$

$$= \frac{1}{2}(C_1 + C_2)\left(\frac{Q_1 + Q_2}{C_1 + C_2}\right)^2$$

$$= \frac{(C_1 V_1 + C_2 V_2)^2}{2(C_1 + C_2)}$$

$\Rightarrow$ diff of charge = Initial energy − ~~fi~~

$$U_i - U_f = \frac{1}{2}C_1 V_1^2 + \frac{1}{2}C_2 V_2^2 - \frac{\left[C_1^2 V_1^2 + C_2^2 V_2^2 + 2C_1C_2V_1V_2\right]}{2(C_1 + C_2)}$$

$$C_1^2 V_1^2 + C_2^2 V_2^2 + C_1 C_2 V_1^2 + C_1 C_2 V_2^2$$

$$\boxed{U_i - U_f = \frac{1}{2}\frac{C_1 C_2}{C_1 + C_2}(V_1 - V_2)^2}$$

$$U_i - U_f > 0$$

$$U_i > U_f$$

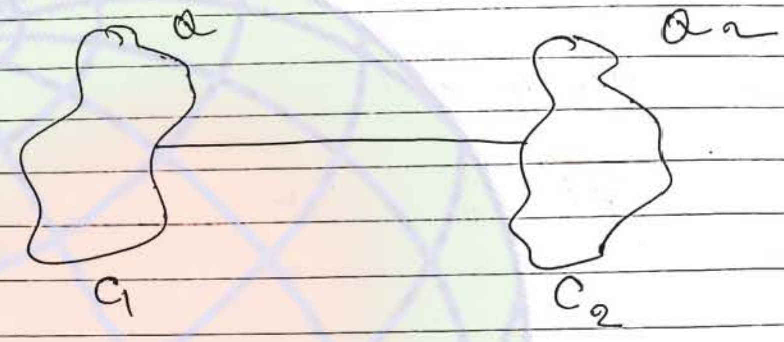
$$\boxed{\Delta U_{Cons.} = \frac{1}{2}\frac{C_1 C_2 (V_1 - V_2)^2}{(C_1 + C_2)}}$$

Energy loss.

Put Q_1, Q_2, V_1, V_2 with sign.

whenever two conducter's of diff' potential are joined together their will be energy loss

$$\boxed{\Delta U_{loss} = \frac{1}{2}\frac{C_1 C_2}{C_1 + C_2}(V_1 - V_2)^2}$$



charge on conducter $= Q_1 + Q_2$

$$V_{common} = \frac{Q_1 + Q_2}{C_1 + C_2}$$

Note → when two conducter of capacitance C_1 and C_2 are joined together it become single conducter of capacitance $C_1 + C_2$

☆ Questions of

Ques) Conductor A of capacitance 4mF and charge 20μC is connected to a neutral conductor B. final ratio of charge on "A" to B is 2:1. Determine energy loss in redistribution.

Sol)

$Q = 20\mu C$

$V_1 = \frac{20}{C_1} = 5$ volt

$V_2 = 0$ volt

$C_1 = 4\mu C$

$C_2 = 2\mu F$

$\frac{Q_A}{Q_B} = \frac{C_1}{C_2}$

$\frac{2}{1} = \frac{4}{C_2}$

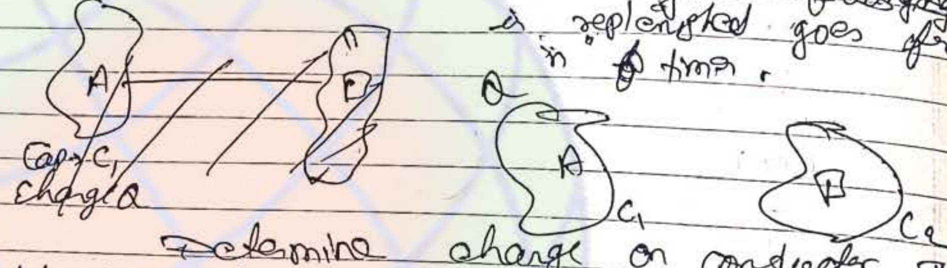
$C_2 = 2\mu F$

Now

$$\Delta U = \frac{1}{2}\frac{C_1 C_2}{C_1+C_2}(V_1 - V_2)^2$$

$= \frac{1}{2}$

Ex 2) Conductor A of capacitance C_1 having charge Q is connect to a neutral conductor B of capacitance C_2. Now it is separated from "A" and conductor A is re-planished with charge Q. Now again conductor B is brought in contact and this whole cycle ~~of~~ is replenished goes for "n" times.



Determine charge on conductor B after "n" cycle

Sol^n Concept →

जब भी n-times लिखा हो समझ जाएँ A mathematical Induction and some progression will come in the picture

1st trial

$$Q_1 = \left(\frac{Q+0}{C_1+C_2}\right)C_2 = \frac{QC_2}{C_1+C_2}$$

2nd trial

$$Q_2 = \left(\frac{Q+Q_1}{C_1+C_2}\right)C_2 = \frac{Q\,C_2}{C_1+C_2} + Q\left(\frac{C_2}{C_1+C_2}\right)^2$$

~~Third trial~~

third trial

$$Q_3 = \left(\frac{Q+Q_2}{C_1+C_2}\right)C_2 = \frac{QC_2}{C_1+C_2} + Q\left(\frac{C_2}{C_1+C_2}\right)^2 + Q\left(\frac{C_2}{C_1+C_2}\right)^3$$

nth trial

$$Q_n = Q\left[\frac{C_2}{C_1+C_2} + \left(\frac{C_2}{C_1+C_2}\right)^2 + \cdots\cdots \left(\frac{C_2}{C_1+C_2}\right)^n\right]$$

$$a = \frac{C_2}{C_1+C_2}$$

$$r = \frac{C_2}{C_1+C_2}$$

$$Q_n = Q\left[\text{Sum of } n \text{ term of G.P}\right]$$

Ex 2) In the same question what max. charge can come on conductor B by this process.

As number of trials are increasing charge on conductor B are increase
when Q_n is maximum

If $n \to \infty$, then Q_n is max.

$$Q_n = \frac{Qa}{1-r} = \frac{QC_2}{C_1}$$

Alt

$V = \frac{Q}{C_1}$ टंका — टंकी $\frac{Q_{max}}{C_2}$

$$\frac{Q}{C_1} = \frac{Q_{max}}{C_2}$$

$$\boxed{Q_{max} = \frac{C_2}{C_1} Q}$$

टंक

~~टंक का change बढ़ेगा जब तक वह टंकी के सामने ना हो जाए~~

टंक का change तब तक बढ़ेगा। जब तक की टंकी के बराबर ना हो जाए।

(Potential of both becomes same)