01/05/17

Physics

Chapter - 1 (Electrostatic)

* **Electro statics :**
charge rest means charge at rest.

* **Charge :**
It is an property of an object by which it Experience and produce electric and magnetic effect.

* **Property of Charge :**

1. Charge is Quantized i.e $Q = \pm ne$
$e = 1.6 \times 10^{-19}$

2. Total charge is conserved (conservation of charge). It is neither Produce or nor destroy. It is only transfer.

3. Charge of an object is independent of speed of object. It is called charge Invariance.

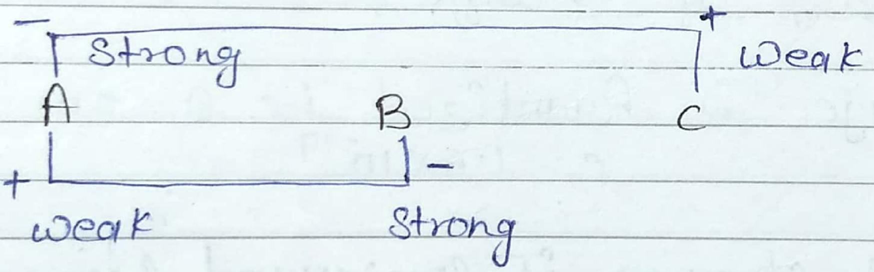
4. Charge can not exist without mass but mass can exist without charge.
(electron mass $= 9.1 \times 10^{-31}$)

* Charging :
It means transfer of electron.

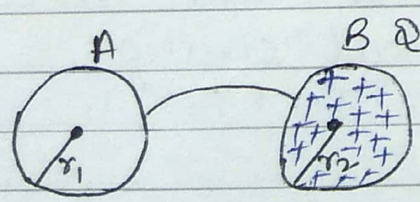
* Methods of Charging :

1. By friction Method :
When two object rubbed against each other Heat is produce due to friction due to Heat and electron transfer from one object to another object and both gets charge.

Que :



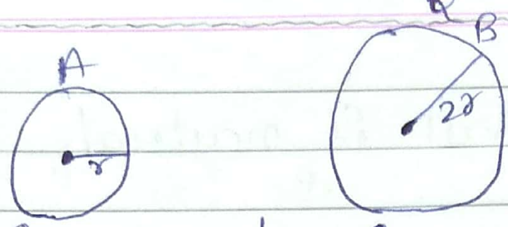
2. Conduction method :
When two Conducting object are made in contact then charge flow from one body to another body or object due to potential difference till Potential becomes equal.



$$q_1 + q_2 = Q$$

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

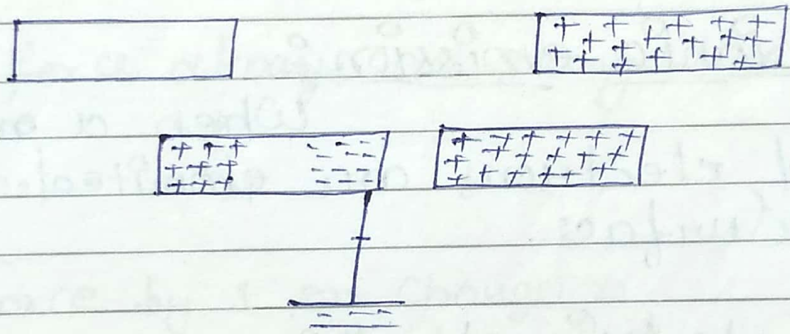
Que:



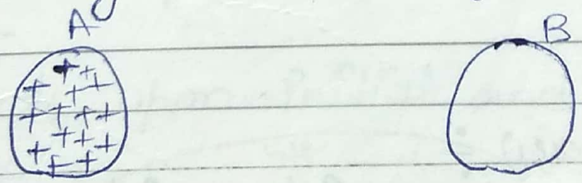
$q_1 = \frac{Q}{3}$ and $q_2 = \frac{2Q}{3}$

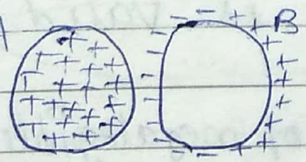
3. Induction Method:

In Induction method charge is not transfered from one object to another. Charge is induced.



- A neutral object can be attracted by a charge object hence attraction is not a sured test of Charge (Nature of charge).





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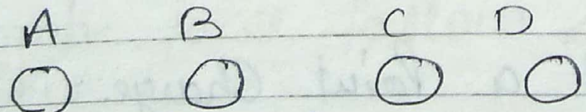

(A, B) attract (A, C) attract, (B, C) Attract find nature of charge A.

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Ans: One of the ball is neutral.

- A neutral object is always attracted by a charged object (weather It is Positive or negative).

* Method of charging :

1. Thermionic emission :
When a matel is heated electrons are emmited by from the Surface.

2. Photo electric effect :
Electrons are emitted by photones from the Surface.
rays of

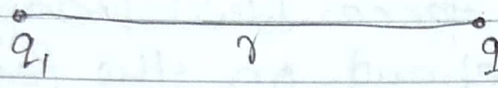
Date : 2/05/17 Tuesday

* Coulomb's Law :
- It is valid for point charge at rest

1) Point charge : It is of negalegible size (Dimensional less)
2) Rest.

- Electron is not a Point Charge.

$\varepsilon_0 = 8.854 \times 10^{-12}$



$f \propto \frac{q_1 q_2}{r^2}$ $\quad f = \frac{k q_1 q_2}{r^2}$

$k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$

ε_0 - Permitivity of free space (vacuum)

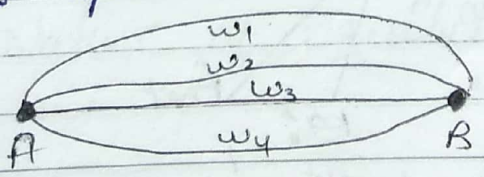
- Coulomb force always act along line of joining and

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

$\vec{f}_{12}$ = force by 1 on charge (2)

- It is a conservated force. It means work done by electrostatics force is independent of the path followed by the particle.

- It depends upon initial and final position.



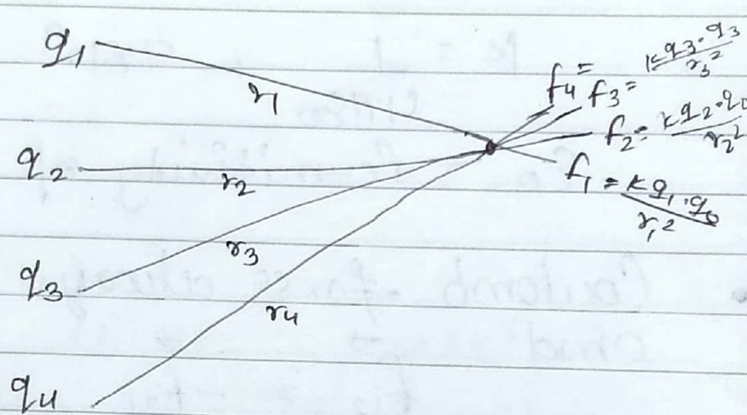
(force)
$w_1 = w_2 = w_3 = w_4$ --- (conservated)

- Coulomb force follow superposition principle

Superposition principle:

Coulombs force b/w two ~~present~~ charges does not depend on the ~~presence~~ present of other charges but net force on a charge is the resultant of the forces ~~a~~ applied ~~part~~ each charge

$f_{net} = f_1 + f_2 + f_3 - - - -$



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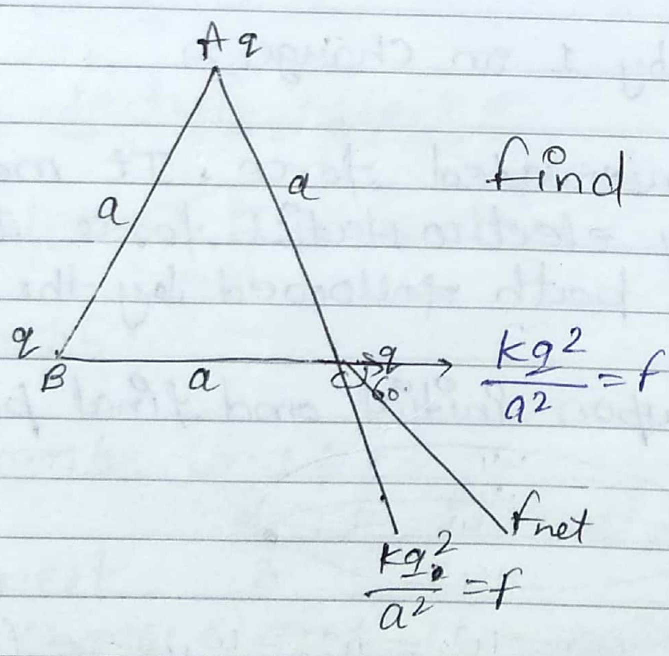


find net force on C.

Ans:

$$f_{net} = \sqrt{a^2 + b^2 + 2ab\cos\theta}$$

$$= \sqrt{f^2 + f^2 + 2f^2 \frac{1}{2}} = \sqrt{3}\, f$$

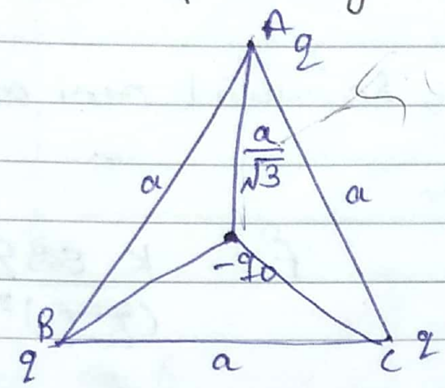
$$= \sqrt{3} \times \frac{kq^2}{a^2} \quad \text{Ans}$$

$$= \frac{3kq}{a}$$

Δ

11. A force charge $-q_0$ is placed at the centroid of triangle. find net force of the Δ.

Ans:

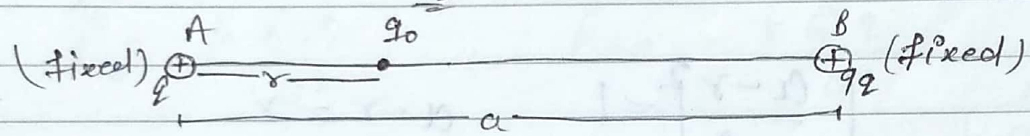


$f_{net} = 0$

$f_{net} = 0$

Que:

eq^b



find r so that charge q_0 remains in eq^m.

Ans:

$$\frac{K q q_0}{r^2} = \frac{K q_0 \cdot 9q}{(a-r)^2}$$

$$r = \frac{a}{4}$$

$\frac{q}{r^2} = \frac{9q}{(a-r)^2}$

$\frac{1}{r^2} = \frac{9}{a^2+r^2-2ar}$

$9r^2 = a^2+r^2-2ar$

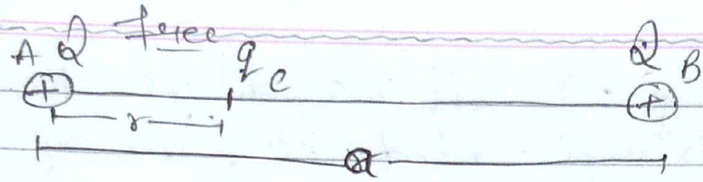
$8r^2 = a^2-2ar$

Que: find Nature of equilibrium

If q_0 is +ve the eq^b is stable along line of joining and unstable $\perp$ to the line of joining

If q_0 is negative the eq^b is unstable along line of joining and stable $\perp$ to the line of joining.

Que:



find Small q and r, so that ~~...~~ on system remains eqb.

$\frac{a}{2}$

Ans

$$f = \frac{k\,\cancel{AC}\,q^2}{r^2}, \quad f = \frac{k\,\cancel{CB}\,q^2}{(a-r)^2}$$

$$\frac{k\,\cancel{AC}\,q^2}{r^2} = \frac{k\,\cancel{CB}\,q^2}{(a-r)^2} = \frac{1}{r^2} = \frac{1}{(a-r)^2}$$

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

$$a = 2r$$

$$\rightarrow \qquad r = \frac{a}{2}$$

Force on A

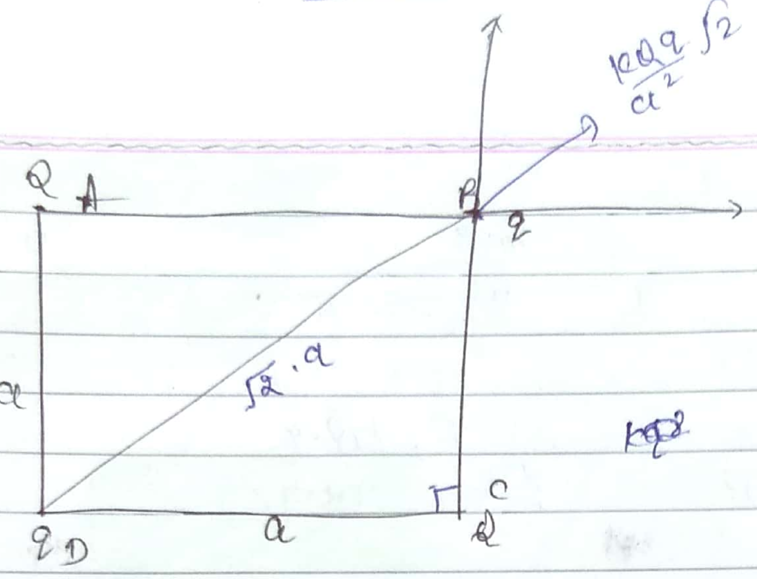
$$\frac{KQq}{(a/2)^2} + \frac{KQ^2}{a^2} = 0$$

$$\frac{4KQq}{a^2} = -\frac{KQ^2}{a^2}$$

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

Fnet ÷

Ex :



$DB^2 = a^2 + a^2$

$DB^2 = 2a^2$

$DB = \sqrt{2a^2}$

$= \sqrt{2}\cdot a$

kq^2

find Q

So, that charge at B remains in eqᵇ.

Ans : $F_{AB} = \frac{kQ\cdot q}{a^2}$, $F_{CB} = \frac{kQq}{a^2}$

$$\boxed{\frac{Q}{q} = \frac{-1}{2\sqrt{2}}}$$ Ans

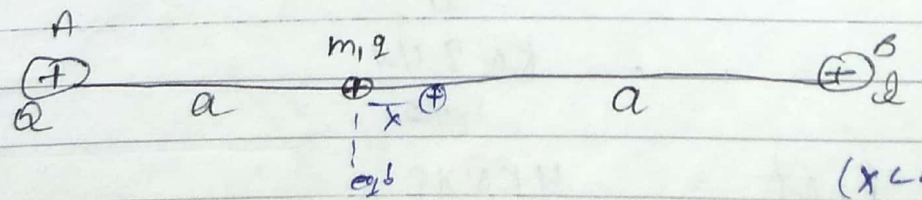
$$F_{DB} = \frac{kq^2}{(\sqrt{2}\cdot a)^2} = \frac{kq^2}{2a^2}$$

$$\left[F_{net} = \sqrt{\left(\frac{kQ\cdot q}{a^2}\right)^2 + \left(\frac{kQq}{a^2}\right)^2 + \left(\frac{kq^2}{2a^2}\right)^2}\right]$$

$$\frac{kq^2}{2a^2} = \frac{-kQq\sqrt{2}}{a^2} = \frac{q}{2} = -Q\sqrt{2}$$

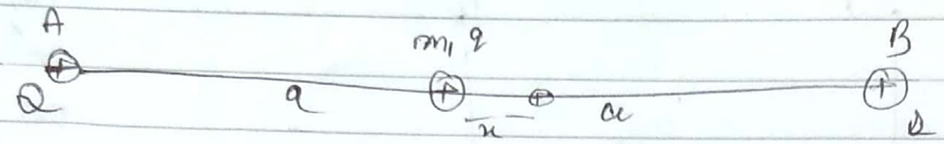
$$\frac{Q}{q} = -\frac{1}{2\sqrt{2}}$$

Que :



$(x << a)$

charge q is likely replaces towards right say distance x and release and so, that it preform SHM find its angular frequency and time Period.



$$f_{AB} = \frac{kQ\cdot q}{(a+x)^2}, \quad F = \frac{kQ\cdot q}{(a-x)^2}$$

$$f_{net} = \frac{kQ\cdot q}{(a+x)^2} - \frac{kQq}{(a-x)^2}$$

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

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

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

$$= kQq\left[\frac{4ax}{(a^2-x^2)^2}\right]$$ $x <<< a$

$$= \frac{kQq\,4ax}{a^4}$$

$$= \frac{kQq\,4x}{a^3}$$

A → $$f_{net} = \frac{4kQxq}{a^3}$$

$f_{net} \propto x$.

Formula $a = F/m$

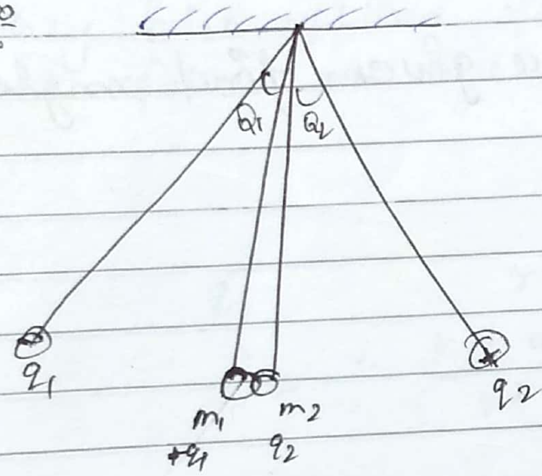
$$a = \left(\frac{4kQq}{ma^3}\right)x$$

$a = \omega^2 x$ (Simple harmonic condition).

ang. freq. $\omega = \sqrt{\dfrac{4KQq}{ma^3}}$

$$\boxed{T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{ma^3}{4KQq}}}$$

Ex:

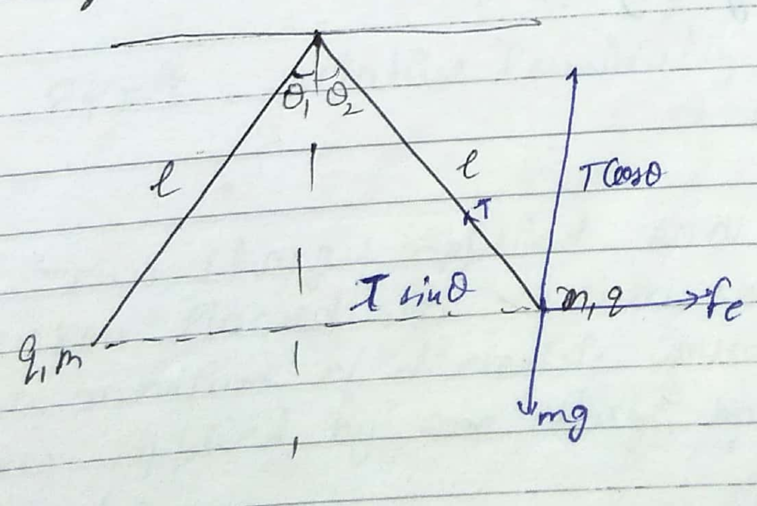


$m_1 = m_2$
$\theta_1 = \theta_2$

If $m_1 < m_2$
then $\theta_1 > \theta_2$

If $m_1 > m_2$
then $\theta_1 < \theta_2$

Ex: Both Balls are equal charge find the value of Charge



$$T\sin\theta = f_e$$
$$T\cos\theta = mg$$

$$\boxed{f_e = \frac{kq^2}{4l^2\sin^2\theta}}$$

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

$$f_e = mg\tan\theta$$
$$\frac{kq^2}{4l^2\sin^2\theta} = mg\tan\theta$$

(ii) Mass and charge are given find angle θ if θ is very small.

$$\theta = \text{very small}$$
$$\sin\theta = \tan\theta = \theta$$

$$\frac{kq^2}{4l^2\sin^2\theta} = mg\tan\theta$$

$$\frac{kq^2}{4l^2mg} = \tan\theta\sin^2\theta$$

$$\theta = \left(\frac{kq^2}{mg4l^2}\right)^{1/3} \Rightarrow$$

F

Date: 03/05/17

Effect of medium of coulombs force:

when charges are placed in a medium force applied by one charge on another charge does not change but net force on one of the charge is changed

Due to charges medium particles gets polarized and they also applied force on the charges. Hence net force on one of the charge.

q_1 —— r —— q_2

$$f_{12} = \frac{k q_1 q_2}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} = f_0$$

q —— r —— q_0

$$f_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_0}{r^2} \qquad (K>1)$$

$$f_{net} = \frac{1}{4\pi\varepsilon_0 K}\frac{q_1 q_2}{r^2} = \frac{1}{4\pi\varepsilon_0 \varepsilon_r}\frac{q_1 q_2}{r^2} = \boxed{\frac{f_0}{K}}$$

$\varepsilon_r = K$ = relative Permittivity of medium.
or Dielectric const. of medium

Que: Two charges applied 60 N force on each other when placed in vaccum. Now they are placed in a medium of dielectric constant for find

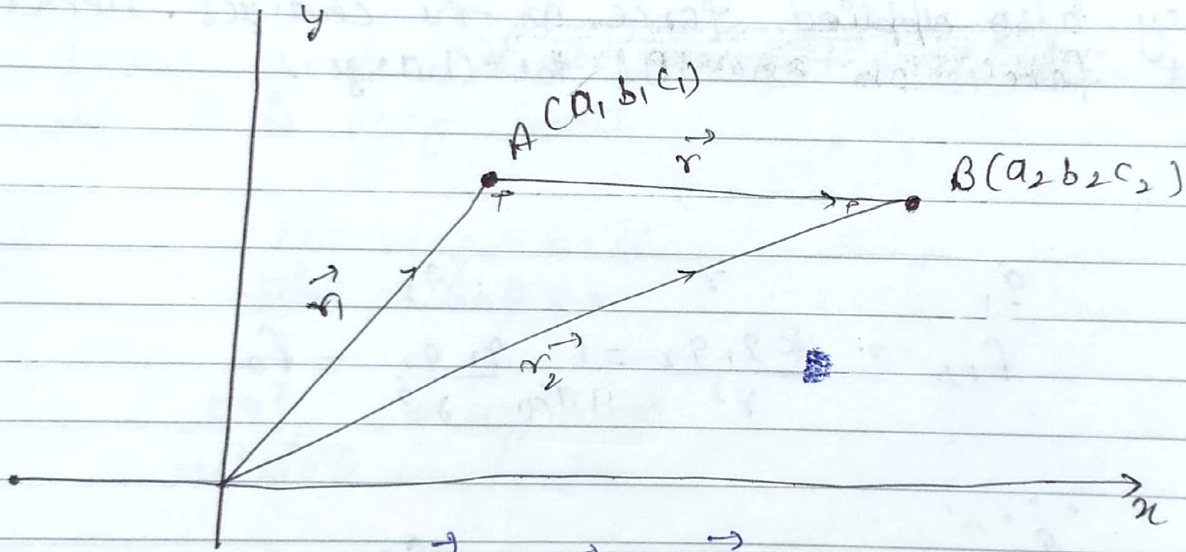
1. Force applied by one charge on another

Ans: 60

(2) Net force on one of the charge.
Ans: 15 N

(3) force applied medium on one of the charge.
Ans: 45 N

* Vector representation of Coulomb's law :



$$\vec{r_1} + \vec{r} = \vec{r_2}$$

$$\vec{r} = \vec{r_2} - \vec{r_1}$$

$$= (a_2 - a_1)\hat{i} + (b_2 - b_1)\hat{j} + (c_2 - c_1)\hat{k}$$

$$|\vec{r}| = \sqrt{(a_2-a_1)^2 + (b_2-b_1)^2 + (c_2-c_1)^2}$$

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

f_{AB} = force on A by B

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

$$\vec{f_{AB}} = \frac{k q_1 q_2}{r^3} \vec{r}.$$

$$\vec{f_{BA}} = -\vec{f_{AB}}$$

$$f_{BA} = -\frac{k q_1 q_2}{r^3} \vec{r}$$

B(4,4,-1)
-1 C

Example:- A(2,3,+1)
+2 C

find f on B due A in vector form

Sol:-

$$\cancel{f_{BA} = \frac{K.2.-1}{r^2} = \frac{-2K}{r^2}}$$

$$\vec{r} \quad \cancel{(4-2)\hat{i} + (4-3)\hat{j} + (1+1)\hat{k}}$$

$$\cancel{\sqrt{\quad}}$$

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

$$|r| = 3$$

$$\vec{f}_{AB} = \frac{k q_1 q_2}{r^2}(-\hat{r})$$

$$= -\frac{k2}{9}\left(\frac{2\hat{i} + \hat{j} - 2\hat{k}}{3}\right)$$

$$= -\frac{2}{3} \times 10^9 (2\hat{i} + \hat{j} - 2\hat{k})$$

Electric field or Electric field intensity :- ($\vec{E}$)

It is a space around a charge in which charge can applied electric force on another charge.

Intensity of electric field at any point is the force on unit positive charge placed at that point.

Test charge always +ve

⊕ q → f

q → test charge

$\vec{E} = \frac{\vec{f}}{q}$ N/C

$f = qE$

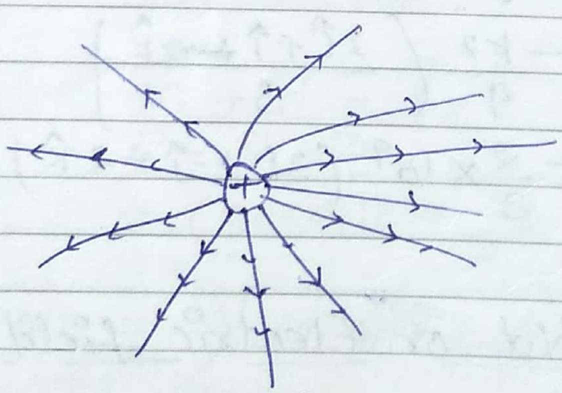
Electric field due to a point charge :

Q ⊕ —— r —— • P → f

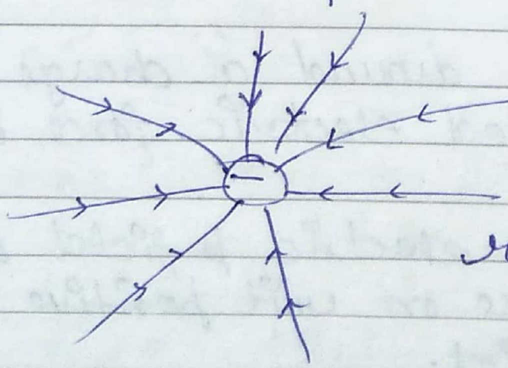
$f = \frac{kQq}{r^2}$

$E_P = \frac{\text{force}}{\text{charge}} \Rightarrow \frac{kQ\cancel{q}}{r^2\cancel{q}}$

$$\boxed{E_P = \frac{kQ}{r^2}}$$

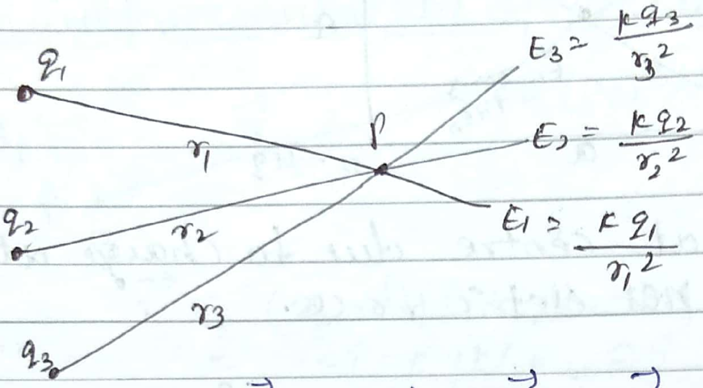


radially outward.



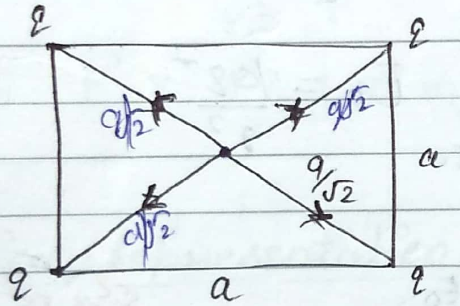
radially Inward

- Electric field follow super position.



$$\vec{E_P} = \vec{E_1} + \vec{E_2} + \vec{E_3} \; - - - - -$$

Ex :

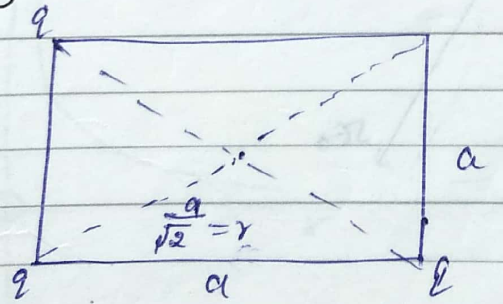


$f_{net} = 0$

Ans

1) One charged is removed find electric field.

Ans :



$\rightarrow$

$$\frac{Kq}{\left(\frac{a}{\sqrt{2}}\right)^2} = \frac{2Kq}{a^2}$$

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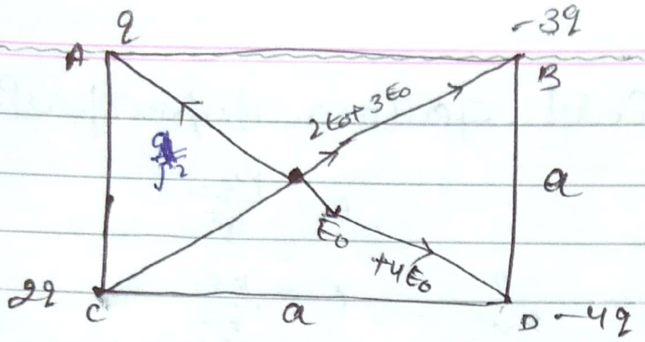
Que:

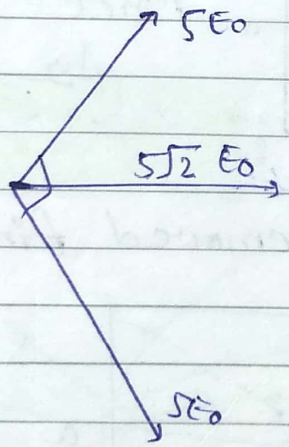


If e.f at centre due to charge at A is E_0 find net electric force.

Ans: $f = \frac{kq.q}{\left(\frac{a}{\sqrt{2}}\right)^2} = \frac{kq^2}{\frac{a^2}{2}} = \frac{kq^2 \times 2}{a^2}$

$E_0 \propto q \qquad E_0 = \frac{kq}{r^2}$

$\Rightarrow$



$5E_0^2 + 5E_0^2 + 2(5E_0)$

$2(5E_0)^2$

$5\sqrt{2}$

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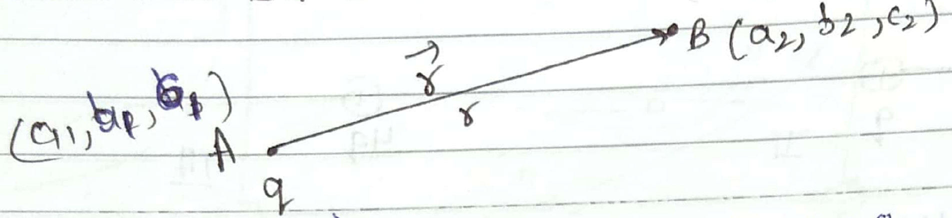
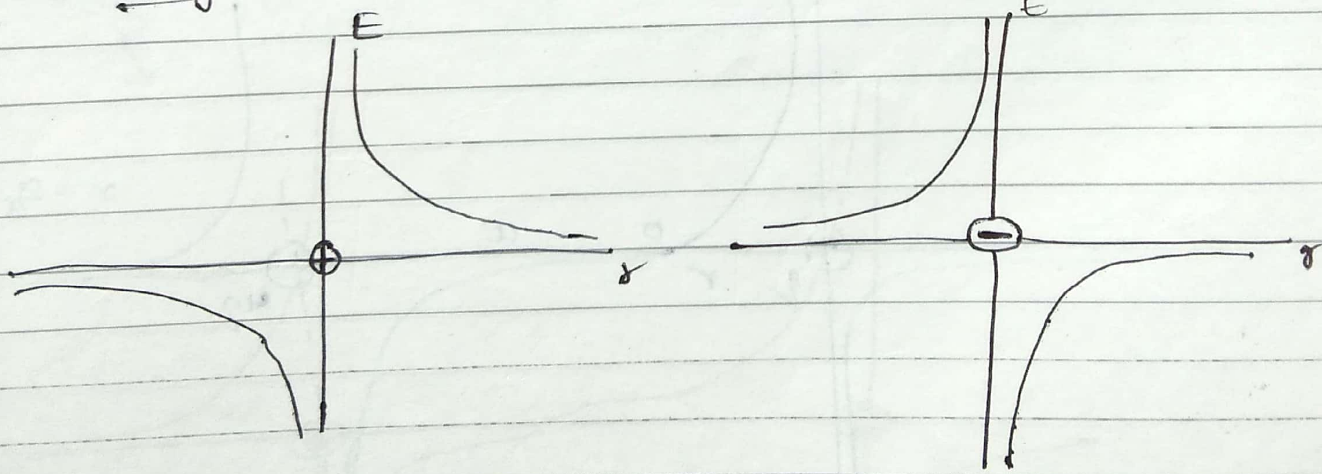
* Vector representation of electric field:



$$\vec{r} = (a_2 - a_1)\hat{i} + (b_2 - b_1)\hat{j} + (c_2 - c_1)\hat{k}$$
$$= x\hat{i} + y\hat{j} + z\hat{k}$$

$$\vec{E} = \frac{Kq}{r^2}\frac{\vec{r}}{r}$$
$$\vec{E} = \frac{Kq}{r^3}(x\hat{i} + y\hat{j} + z\hat{k}).$$

* Graphical Representation of E.f due to point charge:



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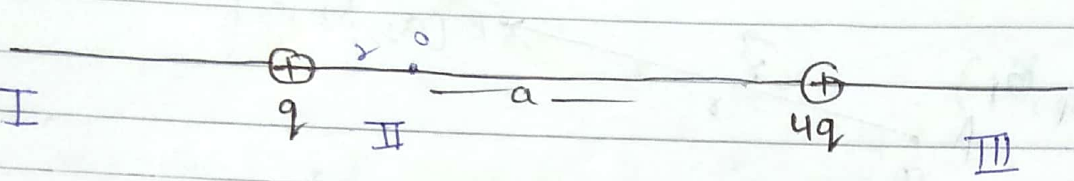
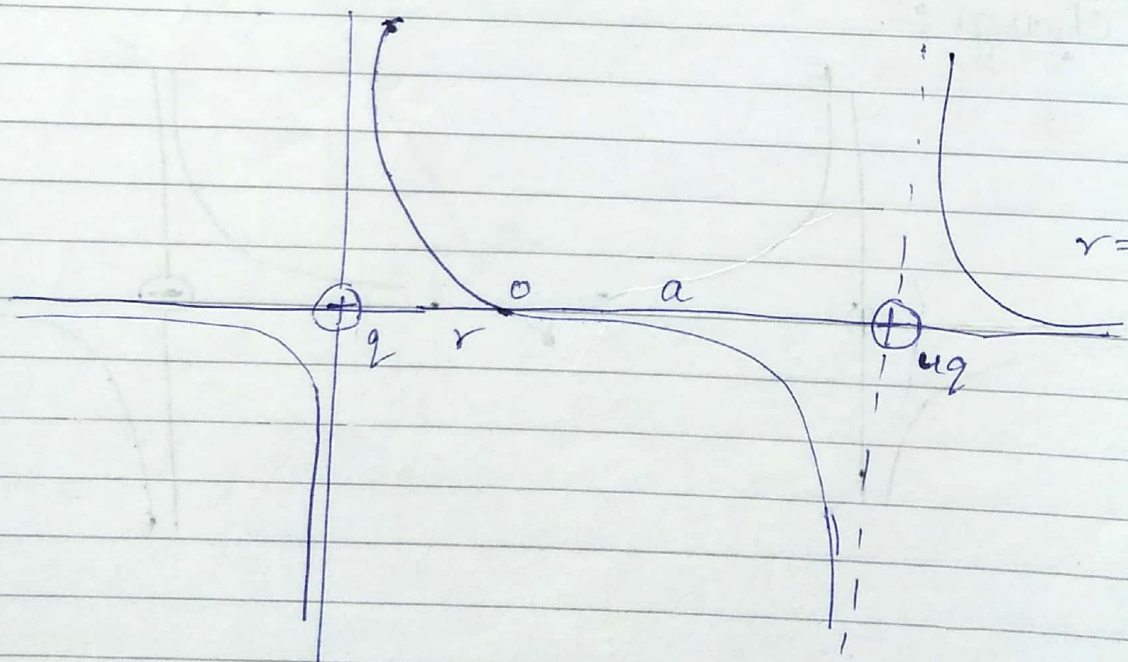
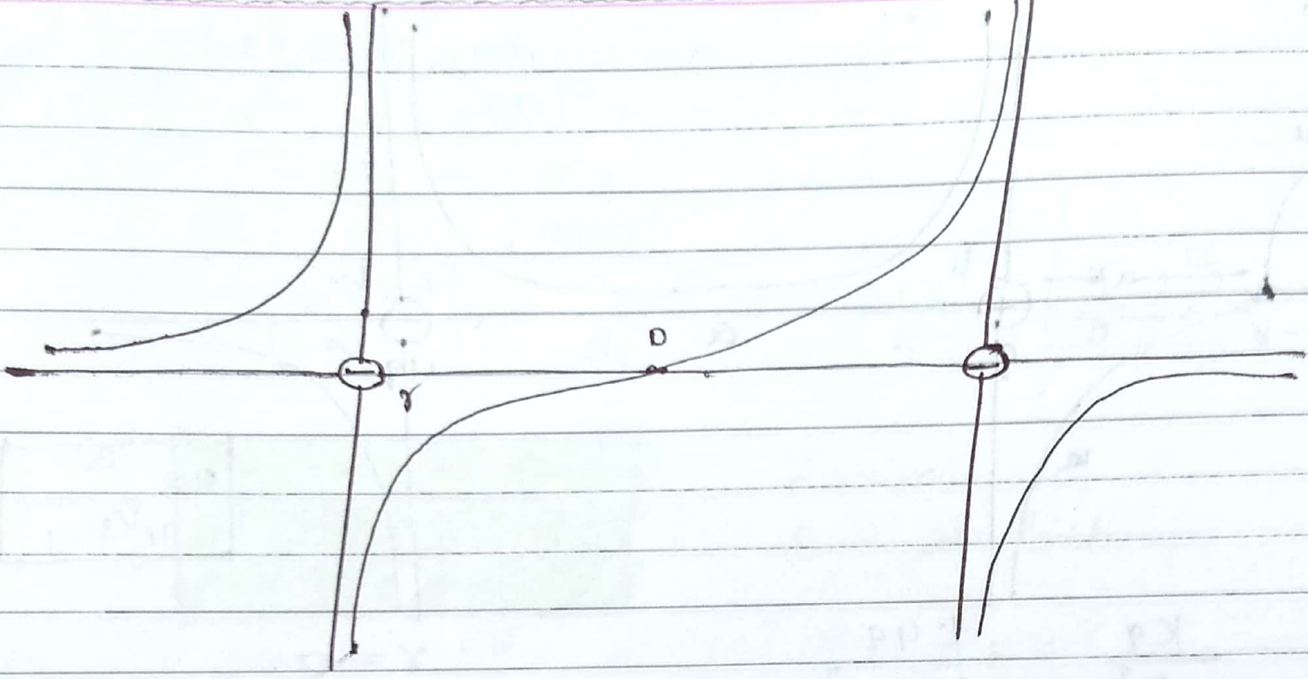
Ex: At what distance from small charge on line of joining net Electric field will be zero.



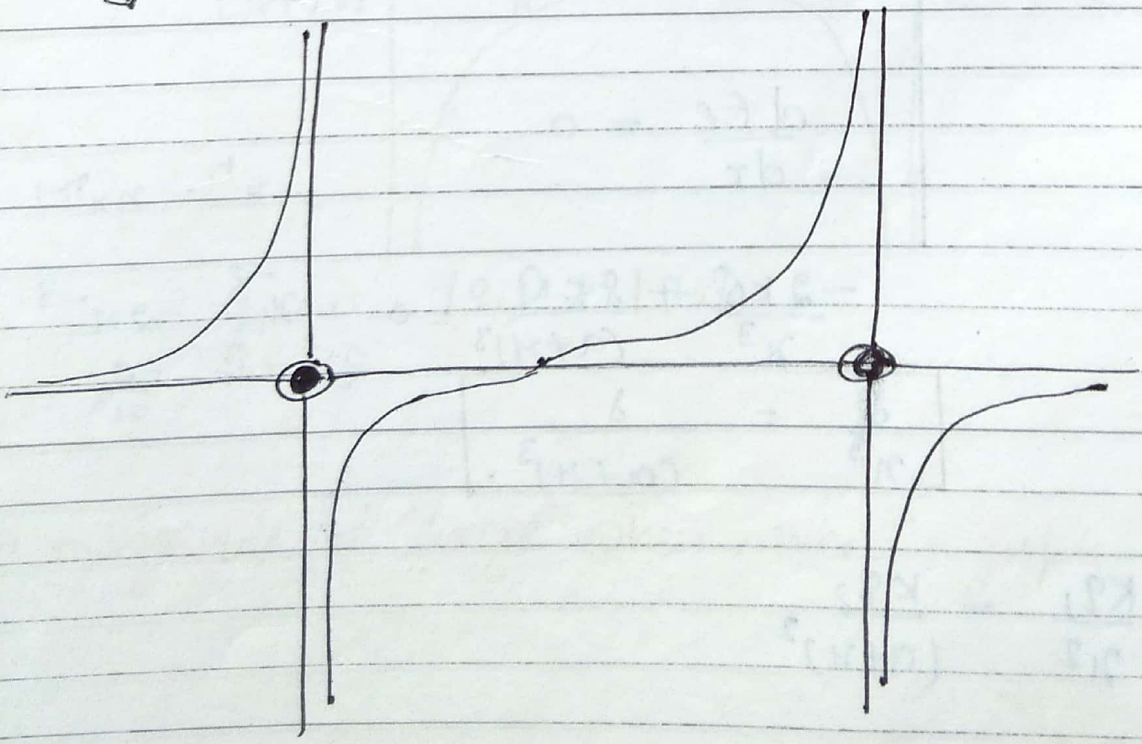
$$\frac{kq}{r^2} = \frac{K4a}{(a-r)^2} \qquad \left[r = \frac{a}{3}\right]$$

- If charges are of same nature the E.f may be zero in b/w the charges and it closed to smaller charge
- If charges are of opposite nature then E.f may be zero outsides the ~~zero~~ charges.





1) both are same same nature.
2) q_1 and q_2 < zero
3) $|q_1| > |q_2|$



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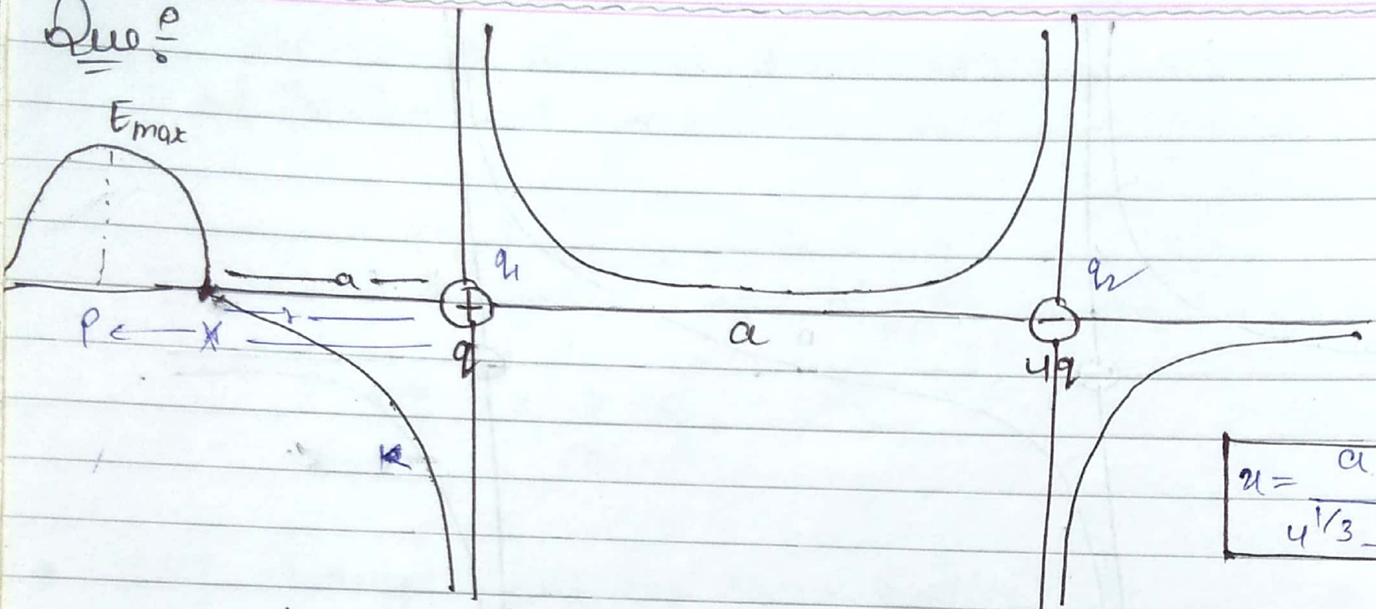


$$\boxed{x = \frac{a}{4^{1/3} - 1}}$$

$$\frac{Kq}{r^2} = \frac{K4q}{(a+r)^2} \qquad r = a.$$

Que: At which point Electric field is maximum.

Ans: $E_P = \frac{KQ}{x^2} - \frac{4Q}{(a+x)^2}$

$\Rightarrow$ $\frac{dE_P}{dx} = 0$

$x^n = nx^{n-1}$

$$\frac{-2KQ}{x^3} + \frac{8KQ}{(a+x)^3} = 0 \qquad x^{-2} = -2x^{-3} = \frac{-2}{x^3}$$

$$\boxed{\frac{2}{x^3} = \frac{8}{(a+x)^3}.}$$

$*$ $\frac{Kq_1}{x^2} - \frac{Kq_2}{(a+x)^2}$

H.W Race : 3

Sheet Ex-I Que : 1 and 2
O-I 1 to 5

$$-\frac{2Kq_1}{x^3} + \frac{2Kq_2}{(a+x)^3} = 0$$

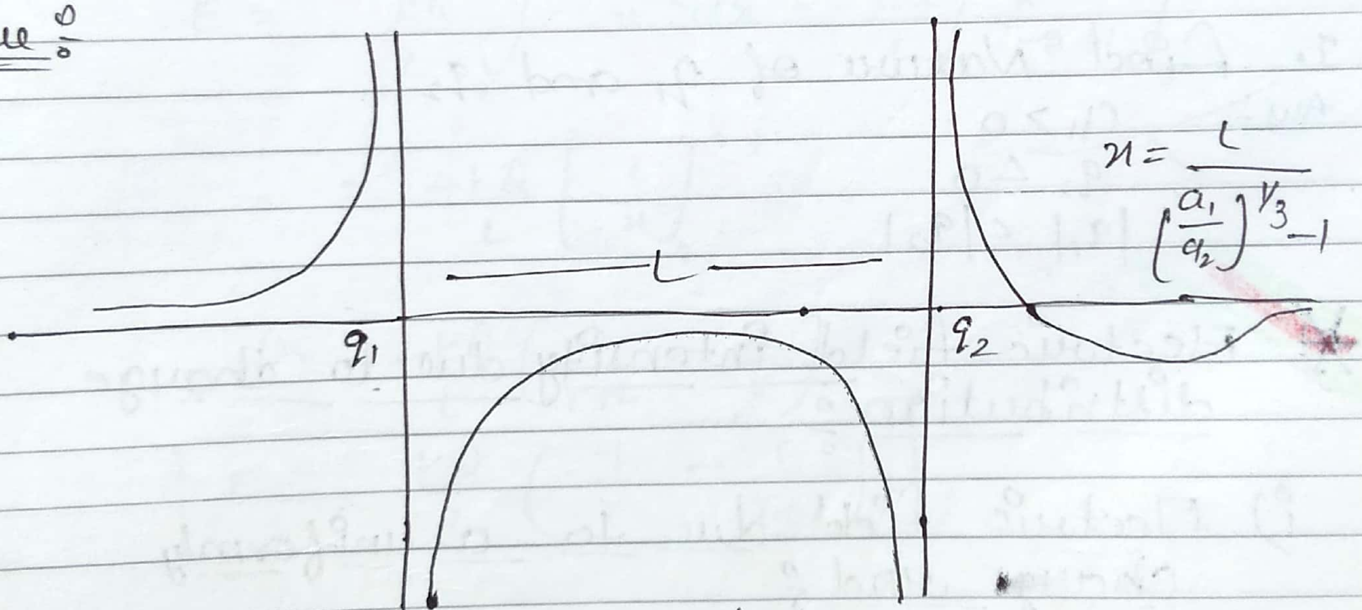
$$\frac{2q_1}{x^3} = \frac{2q_2}{(a+x)^3}$$

$$\left(\frac{a+x}{x}\right)^3 = \frac{q_2}{q_1} \Rightarrow \frac{a+x}{x} = \left(\frac{q_2}{q_1}\right)^{1/3}$$

$$\boxed{x = \frac{a}{\left[\left(\frac{q_2}{q_1}\right)^{1/3} - 1\right]}}$$

maximum E.F at Point

Que :



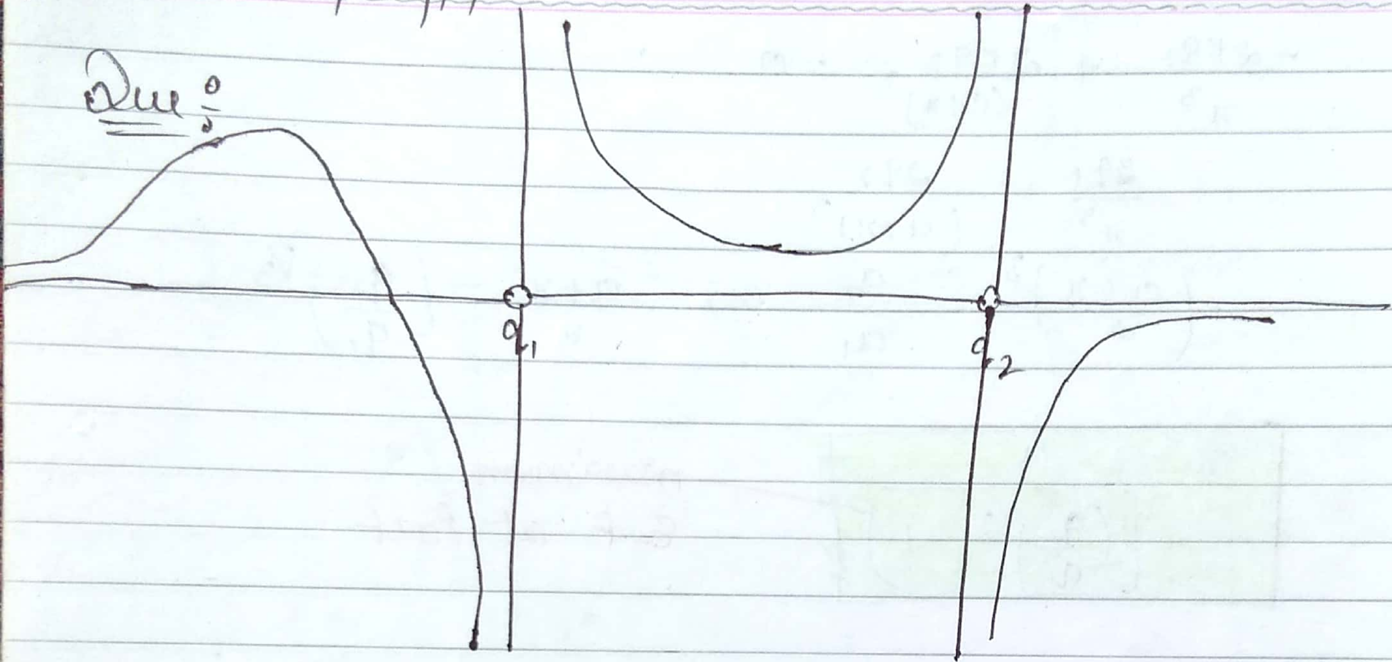
$q_1 < 0$ $|q_1| > |q_2|$
$q_2 > 0$

See magnitude of charge when make its graph.

FRIDAY

Date: 05/05/17

Que:



1. Find Nature of q_1 and q_2

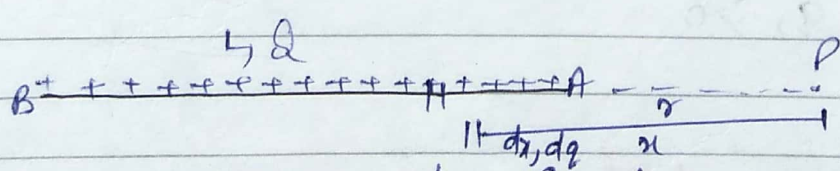
Ans: $q_1 > 0$

$q_2 < 0$

$|q_1| < |q_2|$

Electric field intensity due to charge distribution:

i) Electric field due to a uniformly charge rod:



Linear charge density $\lambda = \frac{\text{Charge}}{\text{length}} = \frac{Q}{L}$ —①

L —— Q

1 —— $\frac{Q}{L}$

dx —— $\frac{Q}{L} \times dx$

E.f due to element $dE = \frac{k\,dq}{x^2}$

from E

$$dq = \lambda\, dx$$
$$= \frac{Q}{L}\, dx$$

$$dE = \frac{kQ}{L}\,\frac{dx}{x^2}$$

$$E = \int_{r}^{r+L} \frac{kQ}{L}\,\frac{dx}{x^2}$$

$$E = \frac{kQ}{L}\int_{r}^{r+L} x^{-2}\,dx = \frac{kQ}{L}\left[\frac{x^{-2+1}}{-2+1}\right]_{r}^{r+L}$$

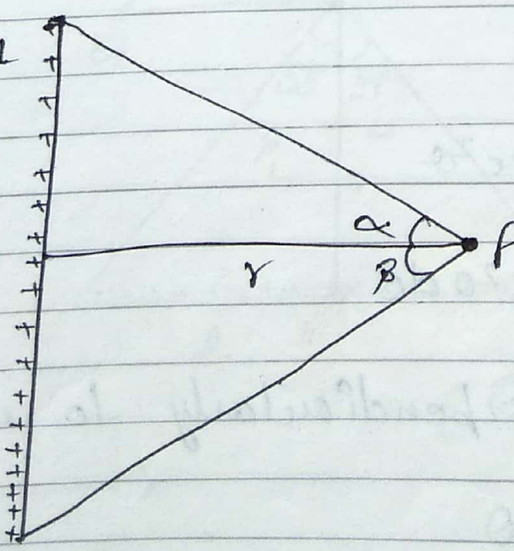
$$= -\frac{kQ}{L}\left[\frac{1}{x}\right]_{r}^{r+L}$$

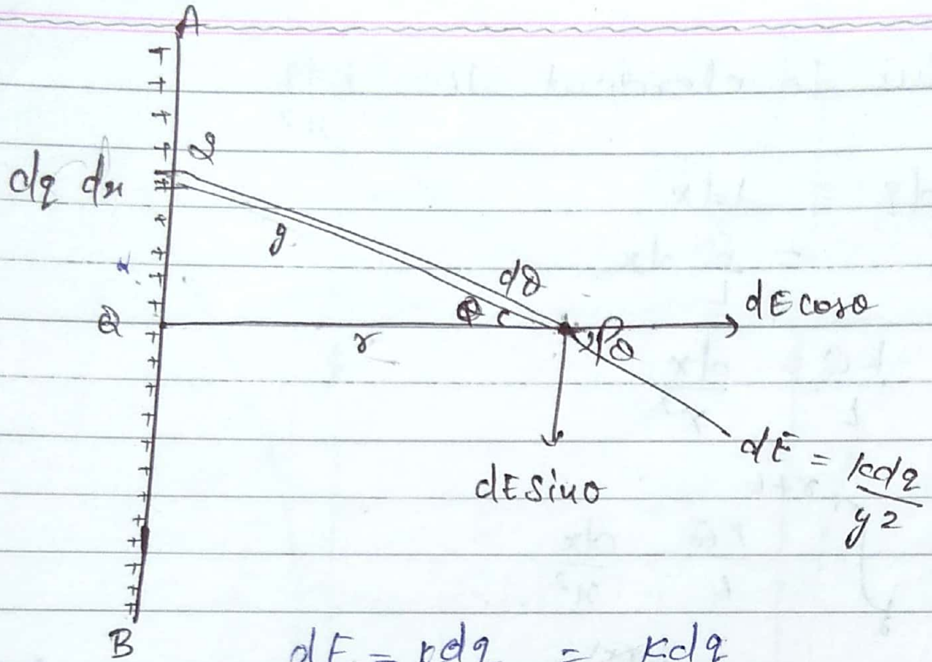
$$E = -\frac{kQ}{L}\left(\frac{1}{r+L} - \frac{1}{r}\right)$$

$$\boxed{E = \frac{kQ}{L}\left(\frac{1}{r} - \frac{1}{r+L}\right)}$$

(ii)

$\lambda = \frac{Q}{L}$





$$dE = \frac{kdq}{y^2} = \frac{kdq}{r^2\sec^2\theta}$$

~~Δ PQS~~

$$dE = \frac{k\lambda dx}{r^2\sec^2\theta} = \frac{k\lambda \cancel{r}\,\cancel{\sec^2\theta}\, d\theta}{\cancel{r^2}\,\cancel{\sec^2\theta}}$$

$$dE = \frac{k\lambda}{r}\, d\theta$$

Δ PQS

$$\cos\theta = \frac{r}{y}$$

$$y = r\sec\theta$$

$$\tan\theta = \frac{x}{r}$$

$$x = r\tan\theta$$

$$\frac{dx}{d\theta} = r\sec^2\theta$$

$$dx = r\sec^2\theta\, d\theta$$

Comp. of E.F. ⊥ Perpendicularly to rod

$$E_1 = \int dE\cos\theta$$

$\left[\cos 37^\circ = \frac{4}{5} \quad \frac{3}{5} \right]$

$$E_1 = \frac{k\lambda}{r} \int_{-\beta}^{\alpha} \cos\theta \, d\theta$$

$$E_1 = \frac{k\lambda}{r} (\sin\theta)_{-\beta}^{\alpha}$$

$$E_1 = \frac{k\lambda}{r} (\sin\alpha - \sin(-\beta))$$

$$E_1 = \frac{k\lambda}{r} (\sin\alpha + \sin\beta)$$

Comp. of E.f I parallel to rod

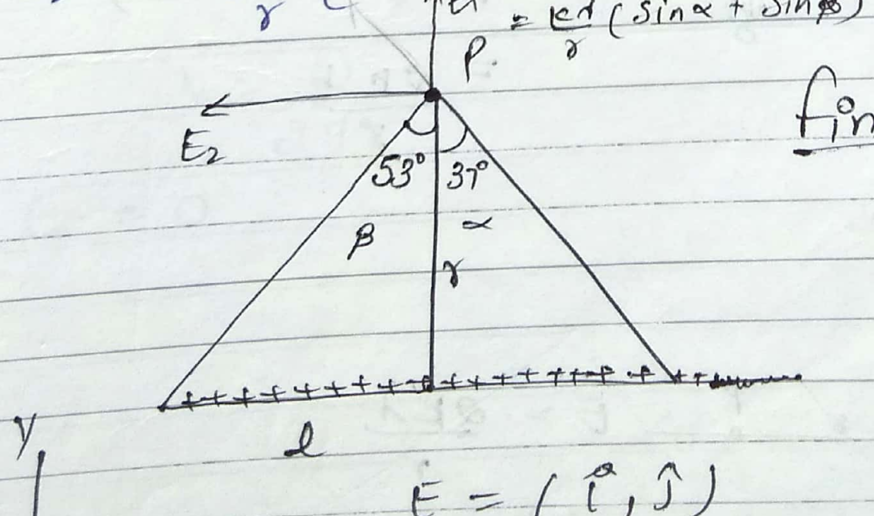
$$E_2 = \int dE \sin\theta = \frac{k\lambda}{r} \int_{-\beta}^{\alpha} \sin\theta \, d\theta$$

$$E_2 = \frac{k\lambda}{r} \left[\cos \right]_{-\beta}^{\alpha}$$

$$E_2 = -\frac{k\lambda}{r} \left[\cos\alpha - \cos(-\beta) \right]$$

$$E_2 = \frac{k\lambda}{r} (\cos\beta - \cos\alpha).$$

Que:



find Electric field

$E = (\hat{i}, \hat{j})$

$\hat{r}$

Ans:

$$E_1 = \frac{k\lambda}{r}(\sin\alpha + \sin\beta)$$

$$= \frac{7}{5}\frac{k\lambda}{r}$$

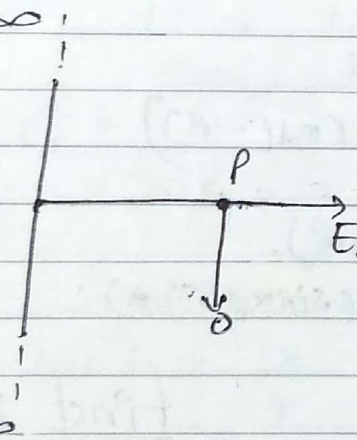
$$E_2 = \frac{k\lambda}{r}(\cos\beta - \cos\alpha)$$

$$= \frac{k\lambda}{r}\left(\frac{3}{5} - \frac{4}{5}\right)$$

$$= \frac{-k\lambda}{5r}$$

$$E = \frac{k\lambda}{5r}\hat{i} + \frac{7k\lambda}{5r}\hat{j}$$

Que: Electric field due to infinitly long rod.

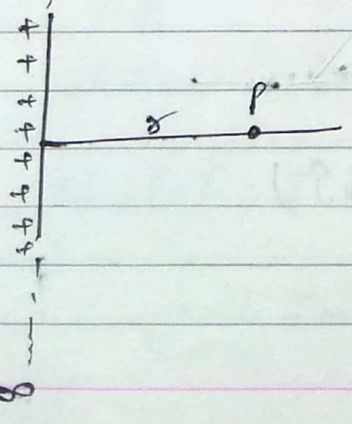


$$\alpha = \beta = 90^\circ$$

$$E = \frac{k\lambda}{r}(\sin\alpha + \sin\beta)$$

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

Q



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

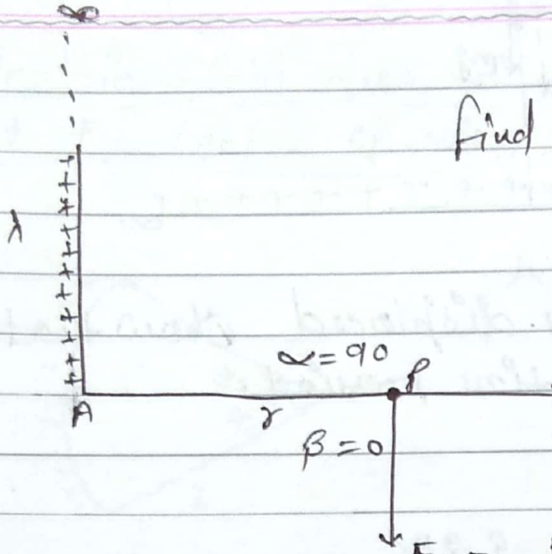
$$\vec{E} = \frac{2k\lambda}{r}\cdot\hat{r}$$

$$= \frac{2k\lambda}{r^2}\vec{r}$$

[H.W Ex- O-1, (6-13) Que. Race-4]

Que:

find Net e.f at B



$E_1 = \frac{k\lambda}{r}(\sin\alpha + \sin\beta)$

$= \frac{k\lambda}{r}$

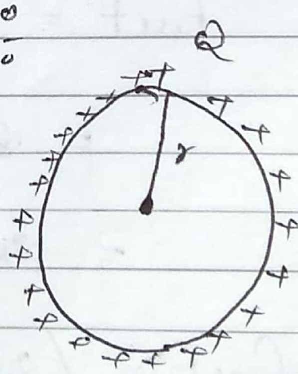
$E_2 = \frac{k\lambda}{r}(\cos\beta - \cos\alpha)$

$= \frac{k\lambda}{r}$

Net Electric. field $\Rightarrow E = \sqrt{(E_1)^2 + (E_2)^2}$

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

* Electric field due to a ring:
uniformly charged ring:



1) At Centre of Ring

$\lambda = \frac{Q}{2\pi r}$

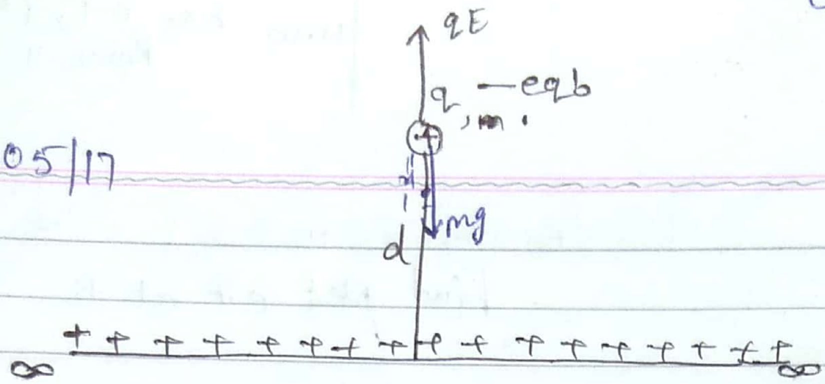
$E_0 = 0$

λ charge density $= \frac{Q}{2\pi r}$ (Q: charge; $2\pi r$: Area of the Ring)

Saturday

Date: 06/05/17

Que:



[Electrostatic mg]

[mg = electrostatic]

Charge q is slightly displaced show that it will perform SHM and time period.

Ans:

$$mg = qE$$

$$mg = q\frac{2k\lambda}{d}$$

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

$$= \frac{2k\lambda q}{(d-x)} - mg$$

$$= \frac{2k\lambda q}{d\left(1-\frac{x}{d}\right)} - mg$$

$$F_{net} = \frac{2k\lambda q}{d}\left(1-\frac{x}{d}\right)^{-1} - mg$$

$$= \frac{2k\lambda q}{d}\left(1+\frac{x}{d}\right) - mg$$

$$= \cancel{\frac{2k\lambda q}{d}} + \frac{2k\lambda q}{d^2}x - \cancel{mg}$$

Binomial

$$\left[(1+x)^n = 1+nx \quad nx \ll 1\right]$$

$$F_{net} = \left(\frac{2k\lambda q}{d^2}\right)x$$

$$a = \left(\frac{2k\lambda q}{md^2}\right)x$$

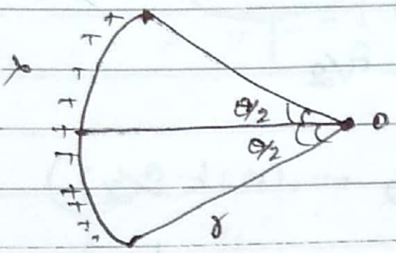
$$a = \left(\frac{g}{d}\right)x$$

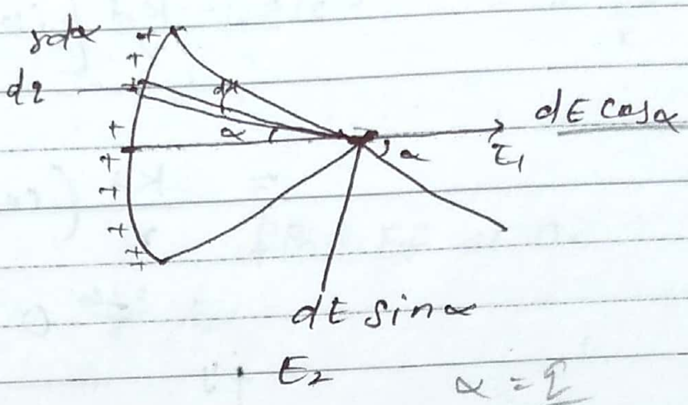
$$\omega = \sqrt{\frac{g}{d}}$$

$$T = 2\pi\sqrt{\frac{d}{g}}$$

$\lambda = \frac{Q}{r\theta}$ radius × angle

(ii) Electric field due to a part of ring:
at the centre of ring:





$\alpha = \frac{l}{r}$

$$dq = \lambda r\, d\alpha$$

$\cancel{dE\cos\alpha}$ $\quad dE = \frac{k\,dq}{r^2}$

$$dE = \frac{k\lambda r\, d\alpha}{r^2}$$

$$dE = \frac{k\lambda}{r}\, d\alpha$$

$$E_1 = \int dE \cos$$

$$= \frac{k\lambda}{r}\int_{-\theta/2}^{\theta/2} \cos\alpha\, dx$$

$$E_1 = \frac{k\lambda}{r}\left[\sin\alpha\right]_{-\theta/2}^{\theta/2}$$

$$E_1 = \frac{k\lambda}{r}\left(\sin\frac{\theta}{2} - (\sin(-\theta/2))\right)$$

$$E_1 = \frac{2k\lambda}{r}\sin\theta/2$$

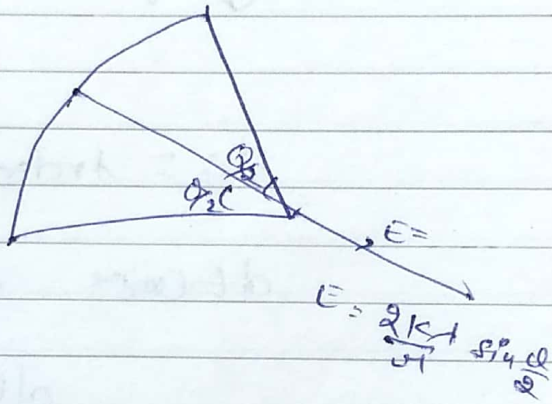
$$E_2 = \int dE \sin\alpha$$

$$= \frac{k\lambda}{r}\int_{-\theta/2}^{\theta/2} \sin\alpha \, d\alpha$$

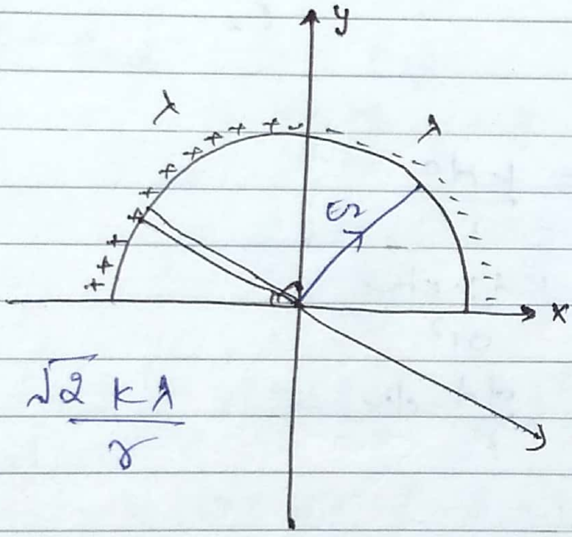
$$E_2 = -\frac{k\lambda}{r}\left[\cos\alpha\right]_{-\theta/2}^{\theta/2}$$

$$= \frac{k\lambda}{r}\left(\cos\theta/2 - \cos(-\theta/2)\right)$$

$$= 0$$



Que:



$$E_2 = \frac{\sqrt{2}\,k\lambda}{r}$$

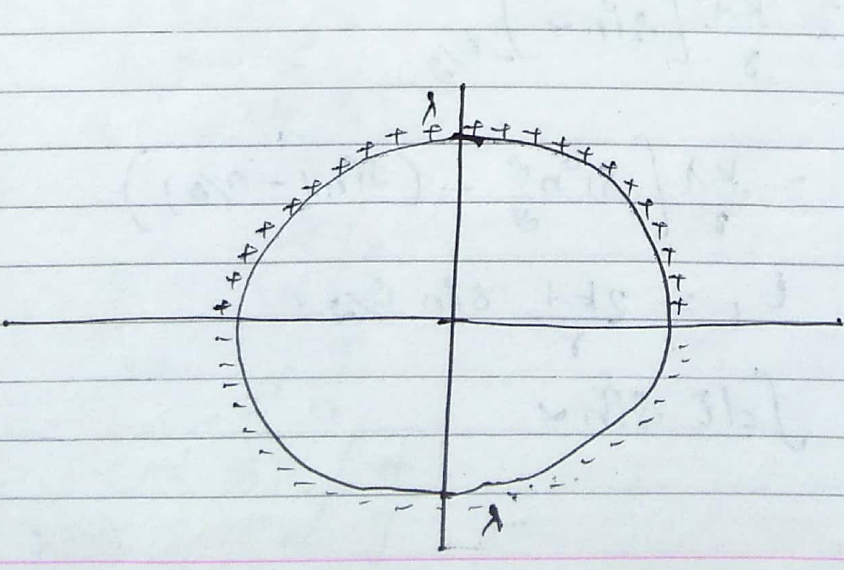
$$E_1 = \frac{2k\lambda}{r}\sin\frac{\theta}{2}$$

$$= \frac{\sqrt{2}\,k\lambda}{r}.$$

Ans:

$$\sqrt{(E_1)^2 + (E_2)^2}$$

Que:
Ans:

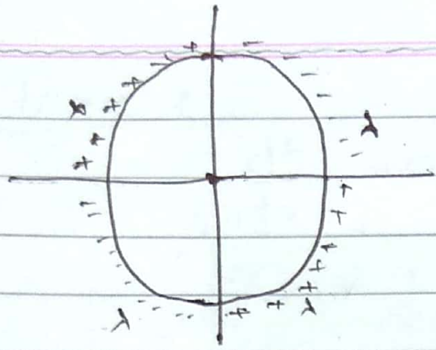


$= \frac{4\pi\lambda}{r}$ Ans

H.W Race-5

HCV = 34-44 => 122/119

Que :

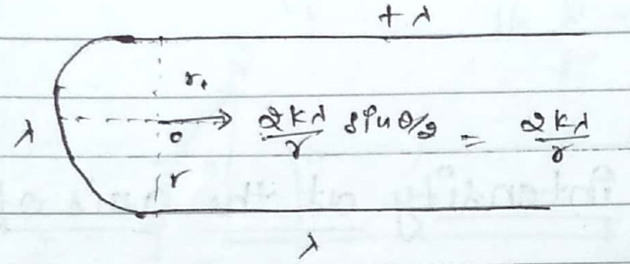


Ans : bottom charges are cancel out

and Ans => $E_1 = \frac{2k\lambda}{r}\sin\frac{\theta}{2}$

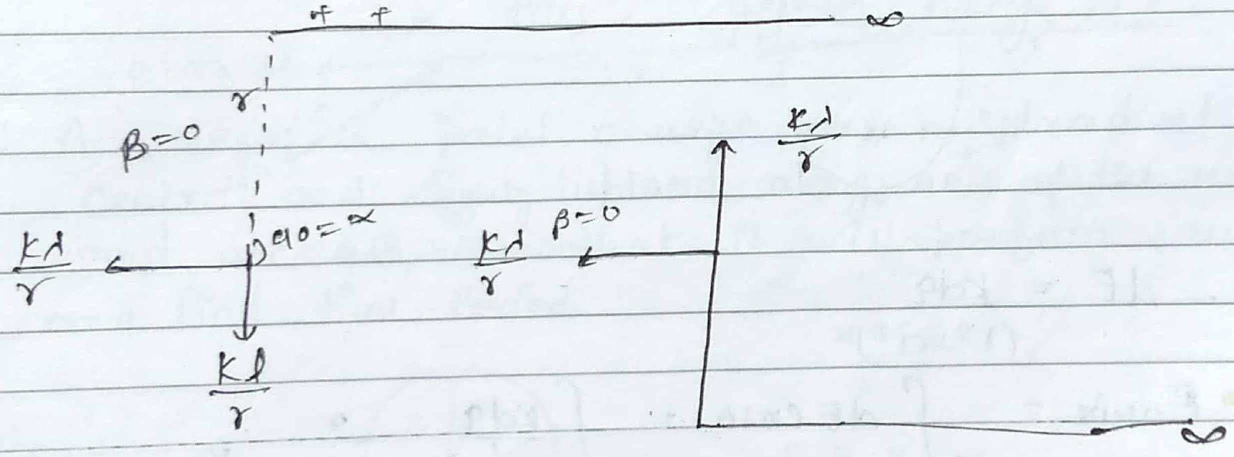
$E_\theta = \frac{\sqrt{2}k\lambda}{r}$ $= \sqrt{2}\frac{k\lambda}{r}$

Que:

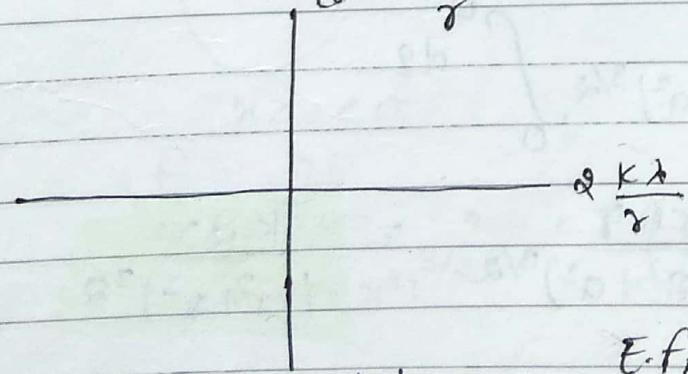


$\frac{2k\lambda}{r}\sin\theta/2 = \frac{2k\lambda}{r}$ Ans

find E.F at O.



$\frac{k\lambda}{r}$ $\frac{k\lambda}{r}$ $\frac{k\lambda}{r}$ $\frac{k\lambda}{r}$



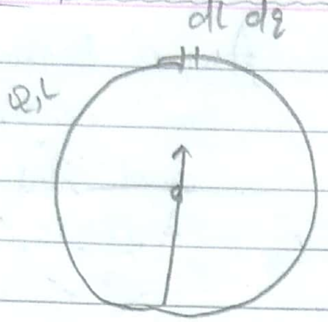
$E_0 = \frac{k\lambda}{r}$

$\frac{2k\lambda}{r}$ $2\frac{k\lambda}{r}$

$E_0 = \frac{k\lambda}{r}$

E.f net = 0.

Date: 08/05/17



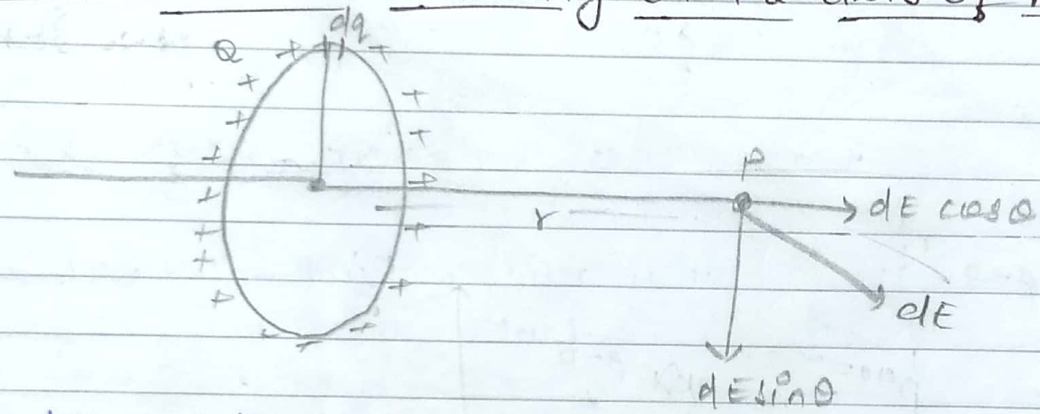
$L = 2\pi r$

$r = \frac{L}{2\pi}$

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

$dQ = \frac{Q}{L} dL$

✱ Electric field intensity at the axis of Ring:



$$dE = \frac{kdq}{(r^2+a^2)}$$

$$E_{axis} = \int dE \cos\theta = \int \frac{kdq}{(r^2+a^2)} \frac{r}{(r^2+a^2)^{1/2}}$$

$$E_{axis} = \frac{kr}{(r^2+a^2)^{3/2}} \int_0^Q dq$$

$$= \frac{kQr}{(r^2+a^2)^{3/2}} = \frac{kQx}{(a^2+x^2)^{3/2}}$$

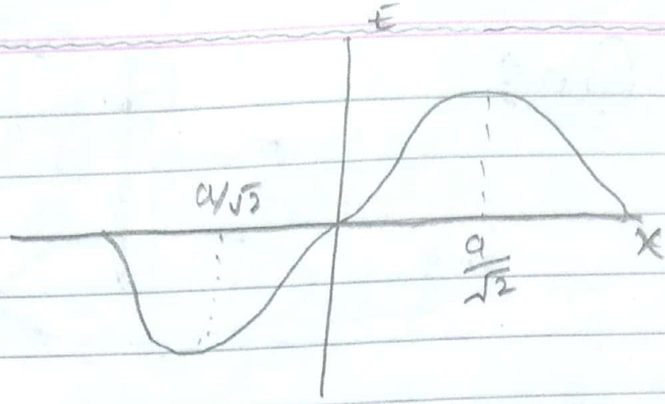
$E \perp$ to axis $= 0$

$E_{centre} = 0$

for max E.f

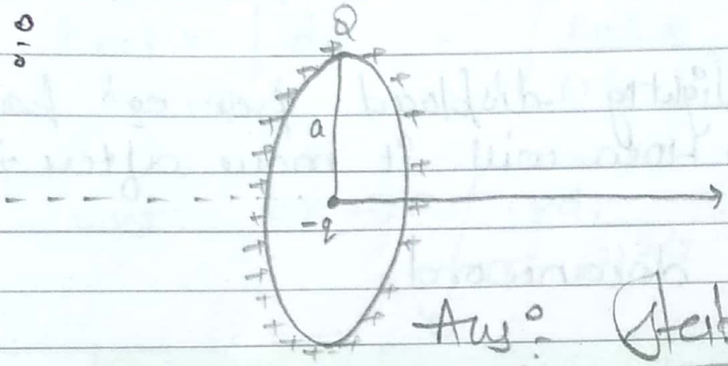
$$\frac{dE}{dx} = 0$$

always → $\boxed{x = \pm \frac{a}{\sqrt{2}}}$



[Circle +]

Que:



[q− stable
q+ unstable]

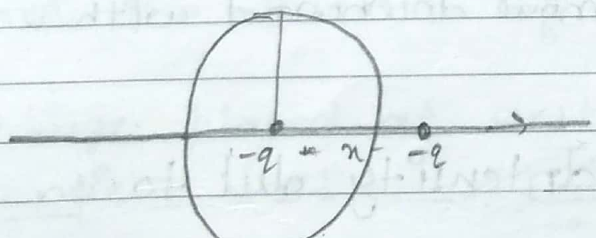
[charge same − unstable]

Ans: Stable charge at centre.

Que: A Negative point charge mass m placed at centre and slightly displaced along axis of the ring and release. Show that it will perform S.H.M and find time Period.

$x \lll a$

Ans:



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

$x \lll a$

$$f = qE$$

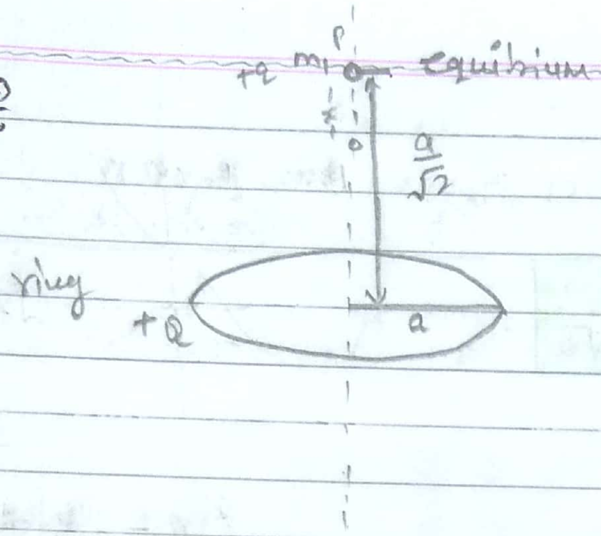
$$f = \frac{kQq}{(a^2+x^2)^{3/2}}\, x = \left(\frac{kqQ}{a^3}\right) x$$

$$acc^n = \left(\frac{kQq}{ma^3}\right) x$$

[Time Period $= \frac{2\pi}{\omega}$]

$$\omega = \sqrt{\frac{kQq}{ma^3}} \qquad = 2\pi\sqrt{\frac{ma^3}{kqQ}}.$$

Que:



Que: Charge q is slightly displaced from eq^b position and Released. How will it move after the release

i) If it displaced downward

Ans:

It will move downward with variable ~~exp~~ acceleration which is increasing

at centre E = 0.

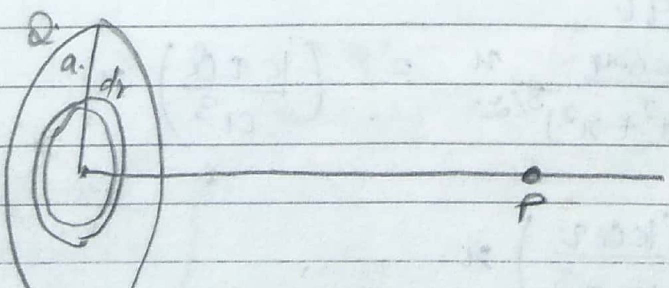
(ii) If it displaced upward.

Then it again move downward with variable acceleration.

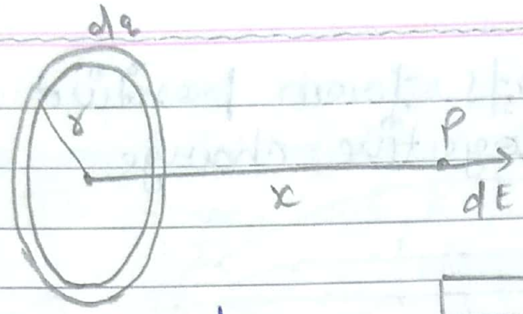
* Electric field Intensity due to a Disc:

I. at the axis of Disk: Surface charge density

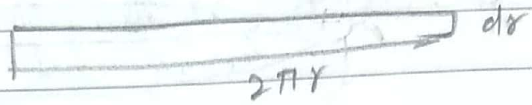
$\sigma = \frac{\text{charge}}{\text{Area}} = \frac{Q}{\pi a^2}$



[E.f - vector quantity]



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



Area = $2\pi r\,dr$

$dq = \sigma 2\pi r\,dr$

$E_{net} = \int dE = \int \frac{k\,dq\,x}{(r^2+x^2)^{3/2}}$ [disc center ≠ 0]

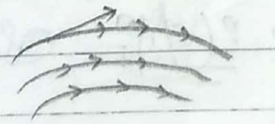
$E_{net} = kx\,\sigma 2\pi \int_0^a \frac{r\,dr}{(r^2+x^2)^{3/2}}$

$$\boxed{E_{net} = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{x}{\sqrt{a^2+x^2}}\right)} \rightarrow \text{Learn}$$

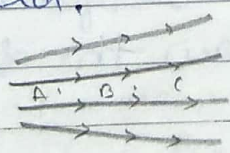
★ **Electric field lines : or Line of force :**

1) These are imaginary curve tangent to which represent the direction of electric field.

2) A charge placed at rest always move tangentily to the field lines

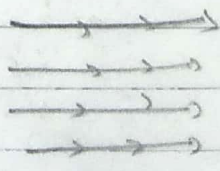


3) Density of field lines represents the magnitude of Electric field.



non-uniform

$E_A > E_B > E_C$



uniform

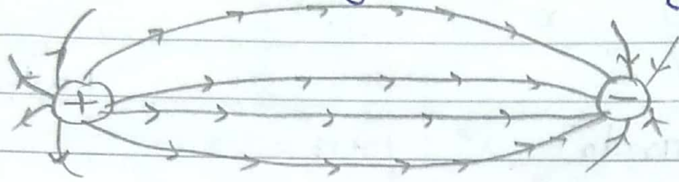
$\vec{E_P} = \vec{E_Q}$ ✗

$|\vec{E_P}| = |\vec{E_Q}|$ ✓

Non-uniform

{Ex-O-1 ÷ 14-23 Que}
{Ex-S-1 ÷ 3, 4, 5 Que}
{H.C.V = 46 - 52 Que.}

3) field lines starts from positive charge and terminate at negative charge



$$\begin{bmatrix} q_1 > 0 \\ q_2 < 0 \\ \frac{q_1}{q_2} = -2 \end{bmatrix}$$

They are not close curved.

4) Two field lines never intersect. because at point of intersection two direction of field are possible which is impossible.

5) No. of field line from a charge is propotional to the magnitude of charge.
from a unit charge the no. of field lines are $\frac{1}{\varepsilon_0}$

Date: 09/05/17

*** Electric flux : (ϕ) :** Scaler quantity (N-m).

- It is defined for a surface
- Electric flux throw a surface is the no. of field lines passing throw the surface

$$\phi = \vec{E} \cdot \vec{A} = EA \cos\theta.$$

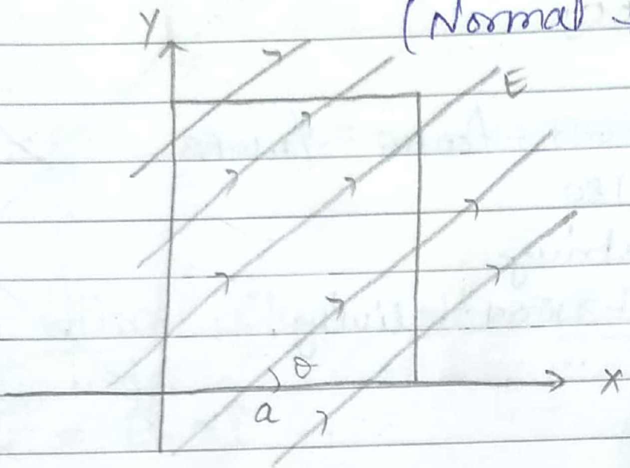
or

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

- Area vector is always perpendicular to the surface and towards outward normal.

θ = Angle b/w $\vec{E}$ & $\vec{A}$ (Normal to the surface)

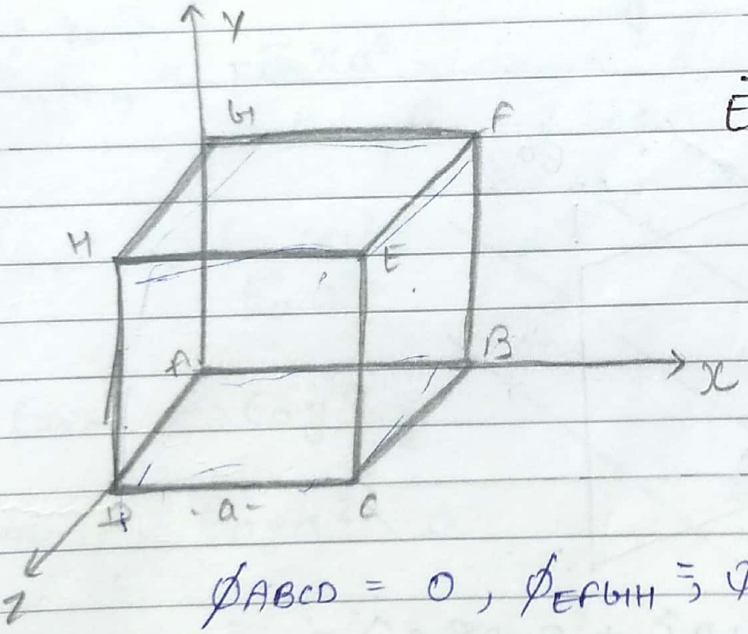
Example:



$\vec{A} = ab\hat{k}$

$\phi = 0$

Que:



$\vec{E} = E_0\hat{i}$.

$\phi_{ABCD} = 0$, $\phi_{EFGH} = \phi_{CDHE} = \phi_{AGFB}$

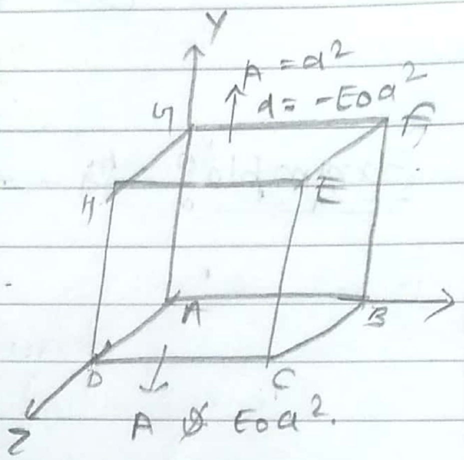
$\phi_{ADHG} = E_0 a^2 \cos 180$
$= -E_0 a^2$ - entering

$\phi_{BCFE} = E_0 a^2 \cos 180°$
$= E_0 a^2$ - leaving.

$\phi_{net} = 0$

Note: Net electric flux throw a close surface in electric field is always zero

$\vec{E} = E_0\hat{i} + E_0\hat{j}$



$\cancel{\phi_{ABCD}} = 0 = \cancel{\phi_{EFGH}} = \cancel{\phi_{CDHE}} = \cancel{\phi_{AGFB}}$

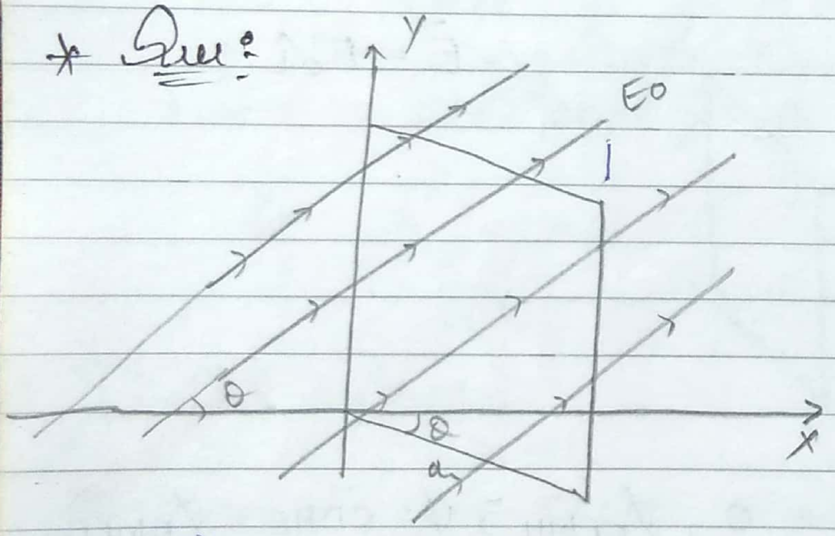
$\phi_{ADHG} = E_0 a^2 \cos 180$

$= -E_0 a^2$ – entring

$\phi_{BCFE} = E_0 a^2 \cos 0 = E_0 a^2$ – living.

$\phi_{net} = 0$

* **Que:**



$\vec{E} = E_0 \cos\theta\,\hat{i} + E_0 \sin\theta\,\hat{j}$

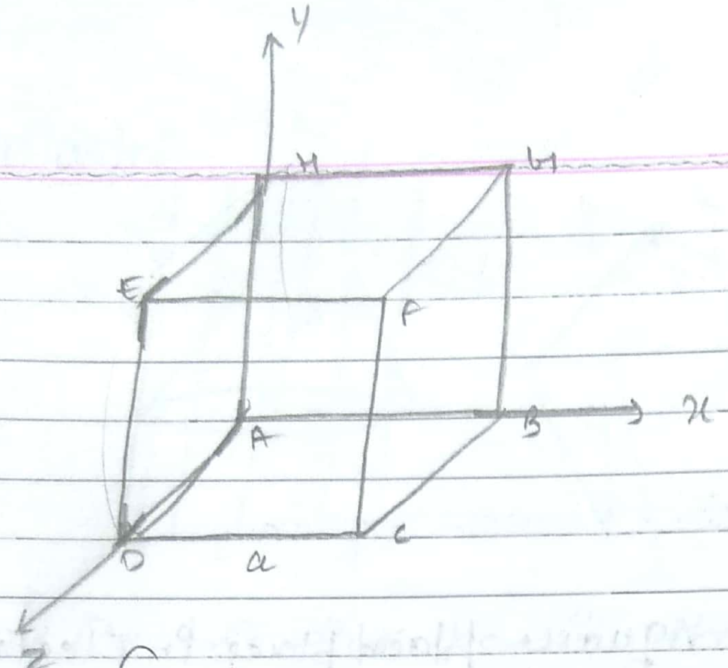
$\vec{A} = -A\sin\theta\,\hat{i} + A\cos\theta\,\hat{k}$

$\phi = \vec{E}\cdot\vec{A} = -E_0 A \cos\theta \sin\theta$

$\phi = -E_0\, ab \sin\theta$

$= \dfrac{-E_0\, ab \sin 2\theta}{2}$

Que:



$\vec{E} = E_0 x \hat{i}$

* find flux throw the cube.

Ans: $\vec{E} = E_0 x \hat{i}$.

$\phi_{ADEH} = -E_0 x a^2$
$= 0$

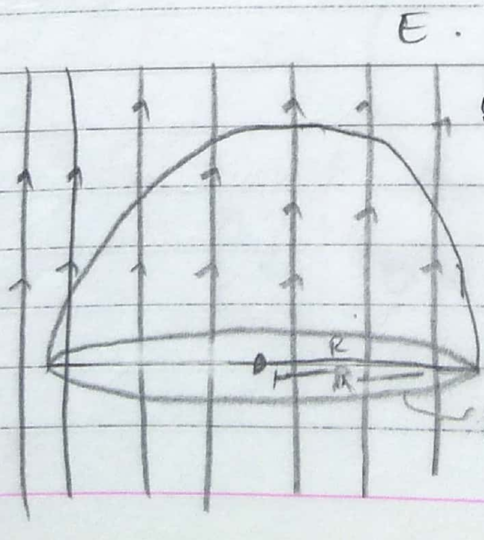
$\phi_{BCFG} = E_0 x a^2$
$= E_0 a^3$.

$E = E_0 x \hat{i} + E_0 y \hat{j}$.

$\phi_{ABCD} = E_0 y a^2 = 0$

$\phi_{EFGH} = E_0 y a^2 = E_0 a^3$

Ex:



Que: find flux passing through curved surface.

$\phi_1 = -\pi R^2 E$

$\phi_1 + \phi_2 = 0$ Ans

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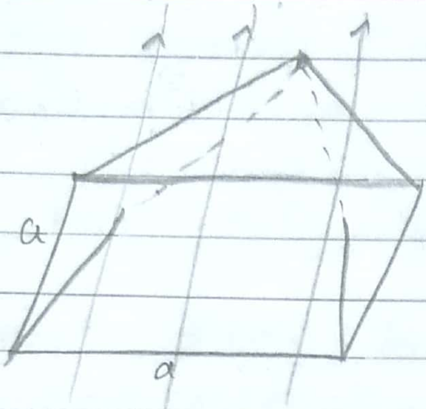
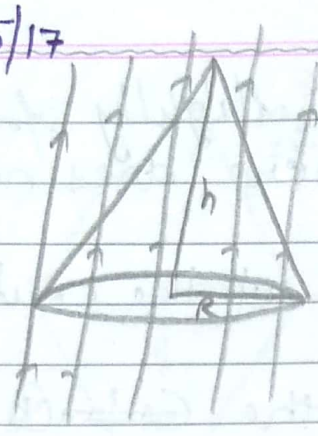
Ex - 0-1 ⇒ Que 80, 81, 82, 83,
100, 101, 102, 108

Que :



Que : A pyramid of square placed place in Electric field passing of the through of pyramed.
find ϕ flux passing throw one of the stantcal surface.

Date: 10/05/17



find Electric flux passing throw the Cone Surface.

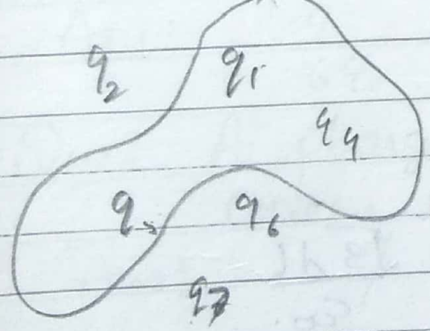
Ans: Net $\phi = 0$

$\phi_1 = -E\pi R^2$

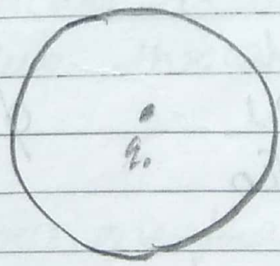
$\phi_1 + \phi_2 = 0$

* **Gauss law:** It is used to calculate flux throw a closed surface due to charge distribution. Net electric flux throw any close surface equals to charge enclosed by the surface divided by ε_0.

$$\phi = \frac{q_{inclosed}}{\varepsilon_0}$$



$$\phi = \frac{q_1 + q_4 + q_5}{\varepsilon_0}$$ Ans



Que:-

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

Note:

* If charge is displaced slightly from centre Then flux throw the sphere does not change

Que: A charge Q place at the centre of Cube find

i) flux passing throw the ~~Cube~~ Cube

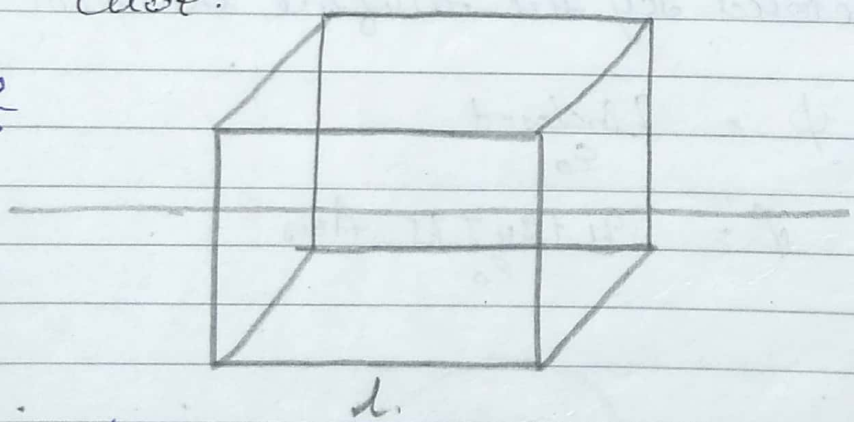
Ans: $\frac{Q}{\varepsilon_0}$

(ii) flux passing throw one phase of the Cube

Ans: $\frac{Q}{2\varepsilon_0}$

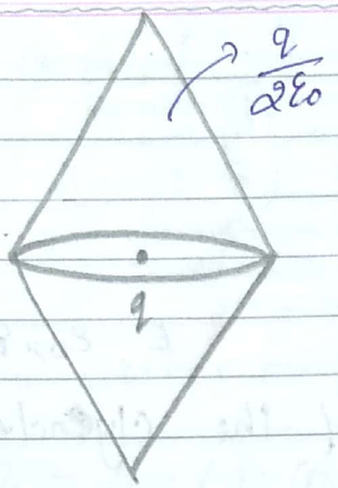
Que: A length a rod of uniform charge density λ and length 3l is placed passing throw a cube of having length of one side l. find maximum and minimum flux throw the Cube.

Ans:



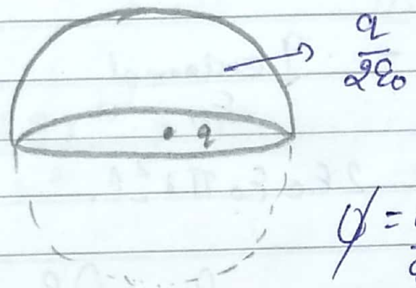
$\phi_{min} = \frac{\lambda l}{\varepsilon_0}$ $\phi_{maximum} = \frac{\sqrt{3}\lambda l}{\varepsilon_0}$

Que :-



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

Que :- 2



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

Que :- 3 A charge Q displace at the centre of the base of Piramed and base of piramid is equilateral triangle. find flux passing throw one of the inclind face of prymid.

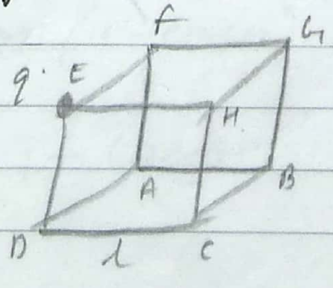
Ans: $\frac{q}{6\varepsilon_0}$

Que: A charge Q placed at one Corner of a Cube. find flux throw the Centre.

Ans: $\phi = \frac{q}{8\varepsilon_0}$

(ii) flux passing throw one phase throw the Cube

Ans: $\frac{q}{24\varepsilon_0}$ Ans



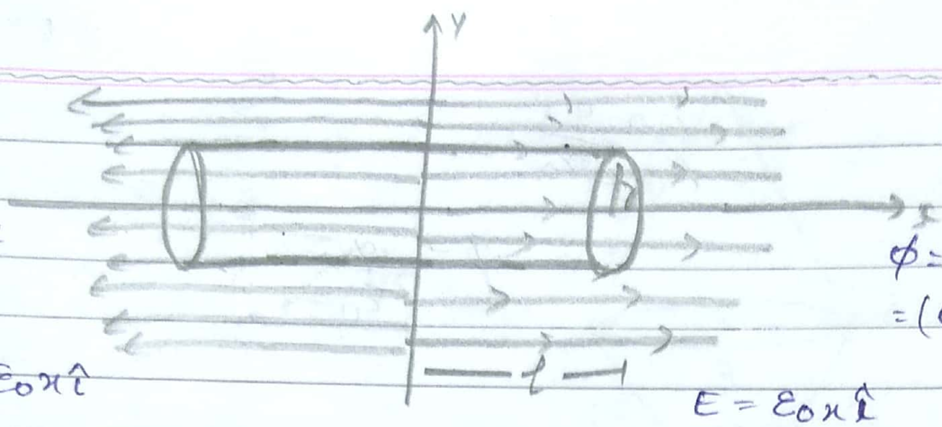
$\phi = 0$ {in current}

Ex:

$E \neq (E_0 l)\pi r^2$

$= E_0 \pi r^2 l$

$E = -E_0 x\hat{i}$



$\phi = (E_0 x)\pi r^2$

$= (E_0 \pi r^2 L)$

$E = E_0 x\hat{i}$

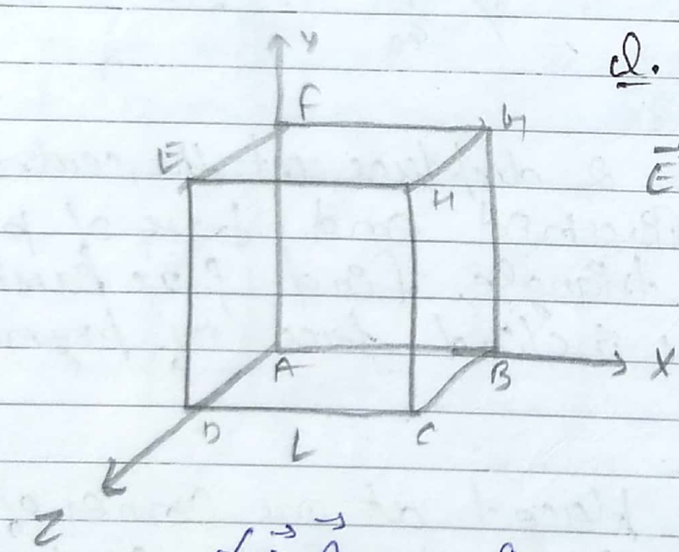
find charge enclosed of the cylinder

Ans! $\vec{E}\cdot\vec{A} = \frac{q}{\varepsilon_0}$

$2E_0\pi r^2 l = \frac{q_{Enclosed}}{\varepsilon_0}$

$q_{in} = 2\varepsilon_0 E_0 \pi r^2 l.$

Que:

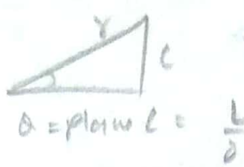


Q. find charge inside the cube.

$\vec{E} = E_0 x\hat{i} + E_0 y\hat{j}.$

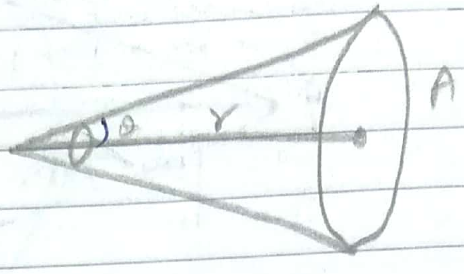
Ans: $\phi\,\vec{E}\cdot\vec{A} = \frac{q}{\varepsilon_0}$

Total $\phi = 2E_0 L^3$ Ans



* Solid angle :- (Ω)

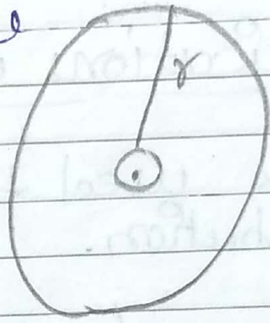
$$\Omega = \frac{A}{r^2}$$



θ - semi-vertex angle

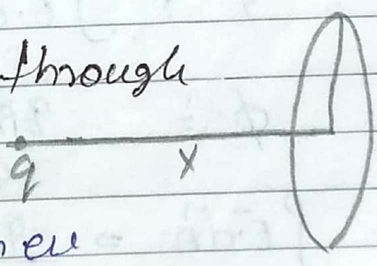
$$\Omega = 2\pi(1-\cos\theta)$$

Que :



$$\Omega = \frac{4\pi r^2}{r^2} = 4\pi$$

Que :- Find flux passed through Disk.



Ans : ~~flu~~ flux throw sphere is $\frac{q}{\varepsilon_0}$

4π - solid angle $= \frac{q}{\varepsilon_0}$

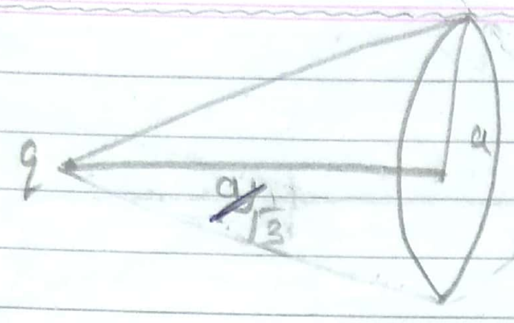
1 ——— ——— $= \frac{q}{4\pi\varepsilon_0}$

Ω ——— $= \frac{q}{4\pi\varepsilon_0} \times$ Solid angle.

$$= \frac{q}{4\pi\varepsilon_0}(2\pi(1-\cos\theta))$$

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

Que:



$\tan\theta = \sqrt{3}$

$\theta = 60$

Ans:

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

* Applications of gauss law:

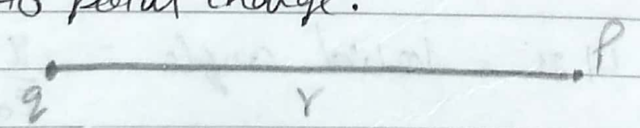
It is used to calculate E.f due to charge distribution.

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

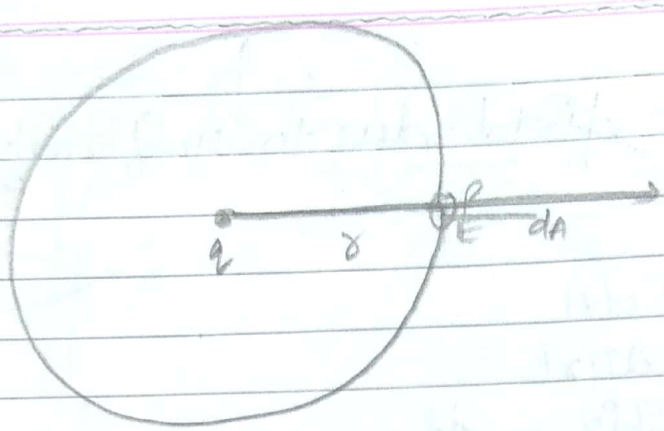
$$\phi = \frac{q_{inclosed}}{\varepsilon_0}$$

$$\int \vec{E}\cdot d\vec{A} \Rightarrow \frac{q_{in}}{\varepsilon_0}.$$

* E.f intensity due to point charge.



1) Construct a surface which symetrically inclosed the charge and passes throw the point where electric field is to be calculated called gassion surface.



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

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

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

$$\phi = \int E \cdot dA$$

$$\phi = \int E \cdot dA = \frac{q}{\varepsilon_0}$$

$$\phi = E \int dA = \frac{q}{\varepsilon_0}$$

$$\phi = E \cdot 4\pi r^2 = \frac{q}{\varepsilon_0}$$

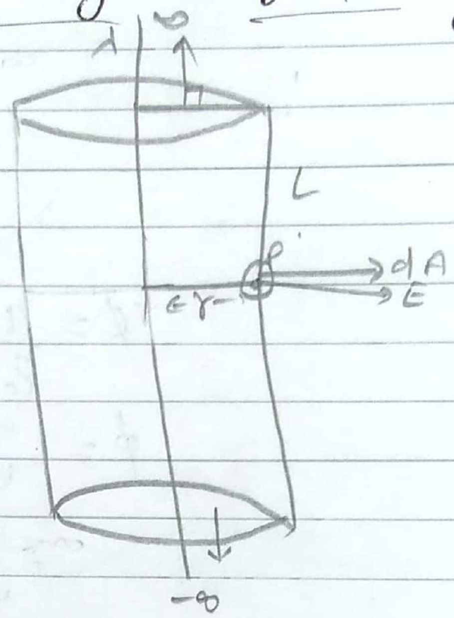
$$E \cdot 4\pi r^2 = \frac{q}{\varepsilon_0}$$

$$E = \frac{q}{4\pi\varepsilon_0 r^2} = \frac{Kq}{r^2}$$

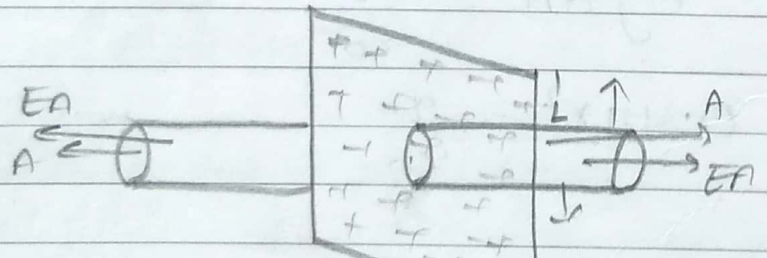
Date: 11/05/17

(2) Electric field due to uniformly charged long wire :

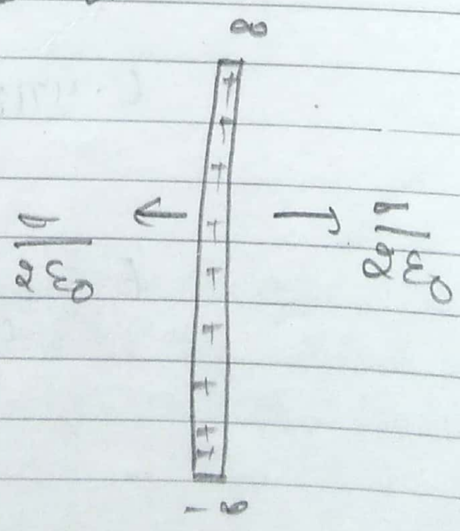
$$\phi = \int E\,dA$$
$$= E\,2\pi r l$$
$$\phi = \frac{q_{in}}{\varepsilon_0} = \frac{\lambda l}{\varepsilon_0}$$
$$E\,2\pi r \cancel{l} = \frac{\lambda \cancel{l}}{\varepsilon_0}$$
$$E = \frac{\lambda}{2\pi\varepsilon_0 r} = \frac{2k\lambda}{r}$$



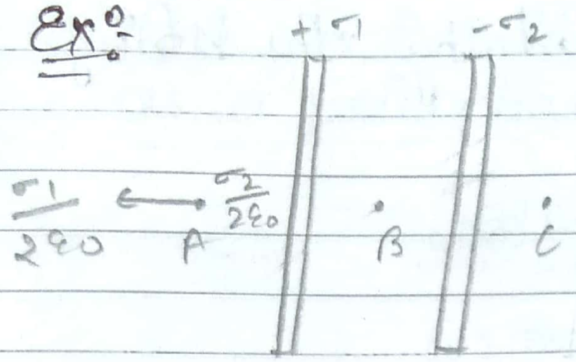
(3) Electric field due to uniformly charged large sheet plane :



$$\phi = 2EA = \frac{q_{in}}{\varepsilon_0}$$
$$2EA = \frac{\sigma \cancel{A}}{\varepsilon_0}$$
$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$



Ex:

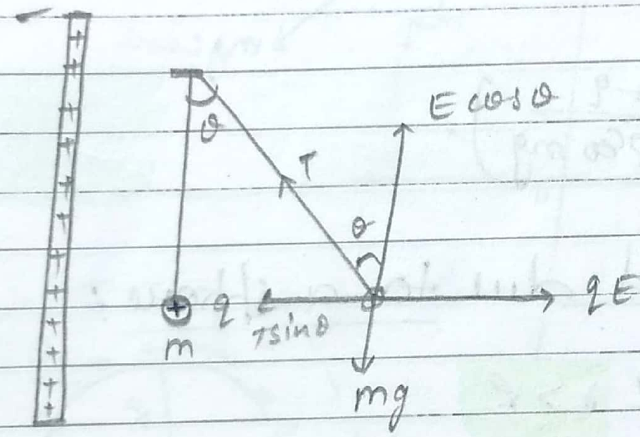


find Net Electric – $E_A = \frac{\sigma_1 - \sigma_2}{2\varepsilon_0}$

$E_B = \frac{\sigma_1 + \sigma_2}{2\varepsilon_0}$

$E_C = \frac{\sigma_1 - \sigma_2}{2\varepsilon_0}$

Que:



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

* find angle made by the string in eqbm:

$T\sin\theta = qE$

$T\cos\theta = mg$

$\tan^{-1}\left(\frac{\sigma q}{2\varepsilon_0 mg}\right)$

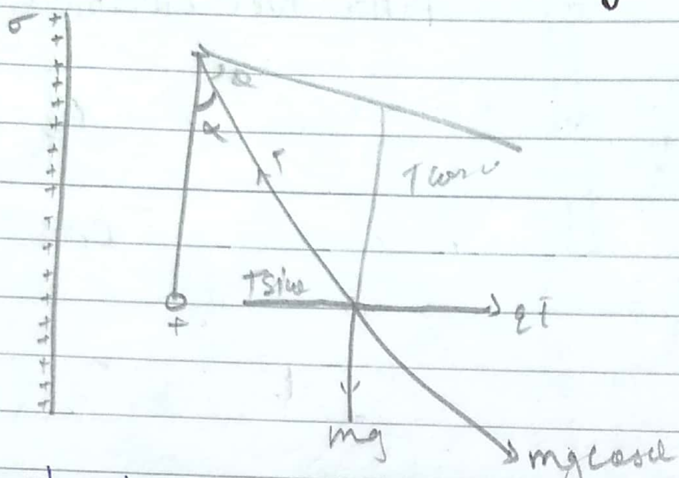
$\tan\theta = \frac{qE}{mg}$

$\tan^{-1} = \frac{\sigma q}{2\varepsilon_0 mg}.$

[maximum => 2× eqm]   Ext. Amplitude / eq3   Ext / Linear Amplitude.

52

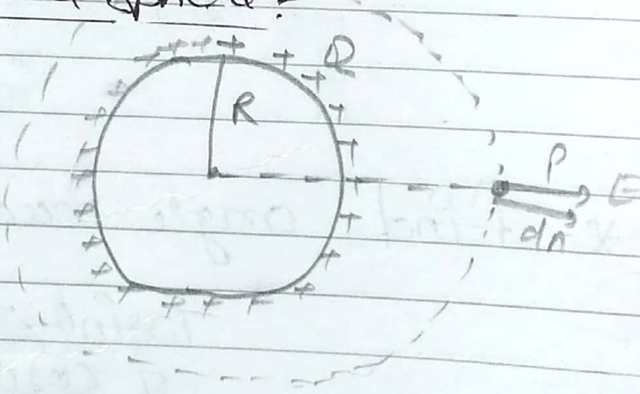
(ii) find maximum angle rotated by the string.



Ans: $\theta = \tan^{-1}\left(\frac{\sigma q}{2\varepsilon_0 mg}\right)$.

(iii) Electric field due to a sphere:

1) Hollow sphere: $r > R$



$$\phi = \frac{q_{in}}{\varepsilon_0} = \frac{Q}{\varepsilon_0}$$

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

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

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

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

$$E_{out} = \frac{Q}{4\pi\varepsilon_0 r^2}$$

$$\boxed{E_{out} = \frac{kQ}{r^2}}$$

same

(iii) Out for Outside point sphere can be considered as a point charge :-

$r < R$

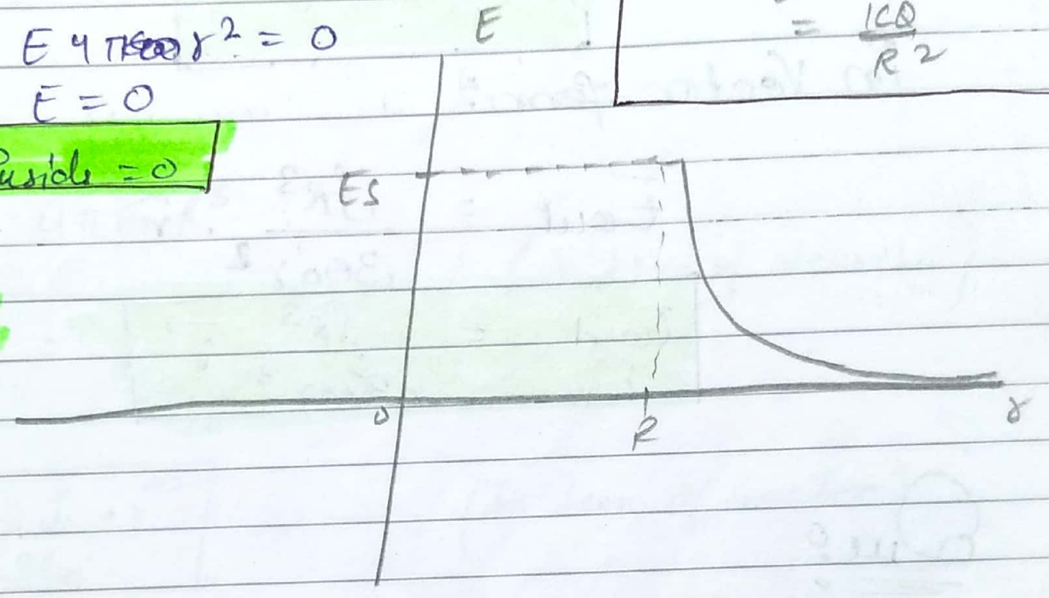
$$\oint E\,dA = \frac{q_{in}}{\varepsilon_0}$$

$$E\,4\pi r^2 = 0$$

$$E = 0$$

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

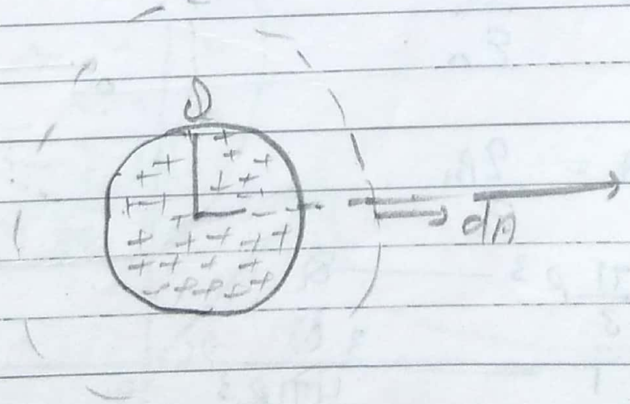
[On Surface Maximum Surface Value $= \frac{KQ}{R^2}$]



$$E_{surface} = \frac{KQ}{R^2}$$

(iv) Uniform charged solid non-conducting sphere :

i) $r > R$



$$\phi = \frac{q_{in}}{\varepsilon_0}$$

$$\oint E\,dA = \frac{Q}{\varepsilon_0}$$

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

Volume charge density

$$\boxed{\rho = \frac{\text{Charge}}{\text{Vol}} = \frac{Q}{\frac{4}{3}\pi R^3}}$$

$$E_{out} = \frac{1}{4\pi\varepsilon_0} \frac{\rho \times \frac{4\pi}{3} R^3}{r^2}$$

ρ

$$\boxed{E_{out} = \frac{\rho R^3}{3\varepsilon_0 r^2}}$$

$\rho =$ const

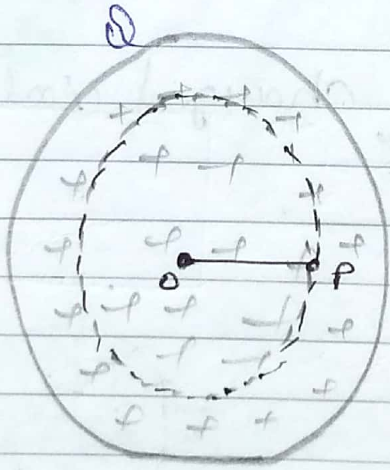
in Vector form:

$$\vec{E}_{out} = \frac{\rho R^3}{3\varepsilon_0 r^2} \cdot \hat{r}$$

$$\boxed{\vec{E}_{out} = \frac{\rho R^3}{3\varepsilon_0 r^3} \vec{r}}$$

Que:

Ans:



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

$$= E \cdot dA = \frac{q_{in}}{\varepsilon_0}$$

$\frac{4\pi}{3} R^3$ —— Q

1 —— $\frac{3Q}{4\pi R^3}$

$\frac{4\pi}{3} r^3$

$$\phi = \frac{q_{in}}{\varepsilon_0} = \int E dA$$

$$\frac{Qr^2}{R^3\varepsilon_0} = E 4\pi r^2$$

$$\boxed{E_{inside} = \frac{Qr}{4\pi\varepsilon_0 R^3}}$$ [in charge term]

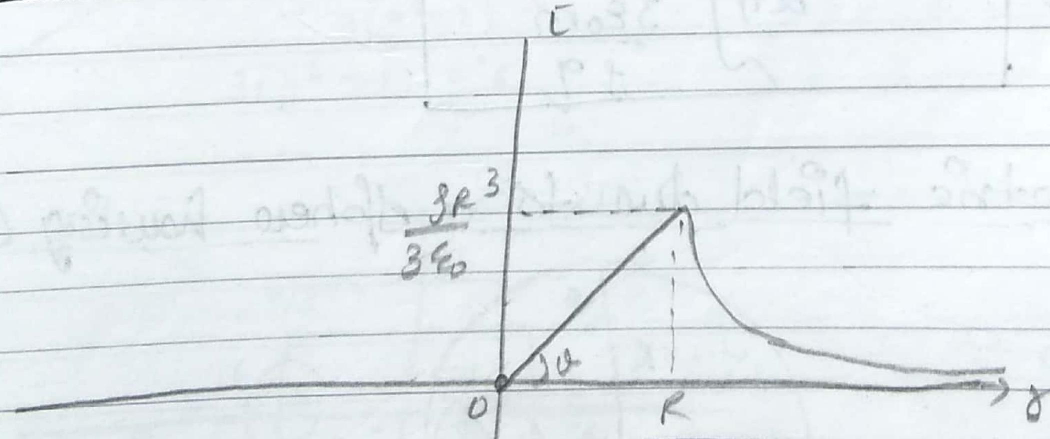
$$E_{inside} = \frac{Qr}{4\pi\varepsilon_0 R^3}$$

(in term of density)

$$\boxed{E_{inside} = \frac{\rho r}{3\varepsilon_0}}$$

$$\boxed{\vec{E}_{inside} = \frac{\rho}{3\varepsilon_0}\vec{r}}$$ (In term of vector)

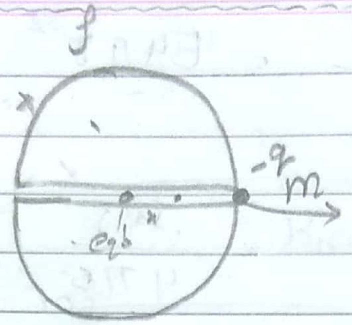
$$\boxed{E_{surface} = \frac{\rho R}{3\varepsilon_0}}$$



$$\boxed{\tan\theta = \frac{\rho}{3\varepsilon_0}}$$

H.W [Ex-8-2 ⇒ 4,5
O-1 ⇒ 27,29
J-A ⇒ 6,10,16,17,19,29,33,35]

Que:



⇒ A negative charge is release and at one of the tunnel so, that it will perform S.H.M and find its time period.

Ans:

$$E = \frac{\rho x}{3\varepsilon_0}$$

$$f = qE = \frac{q\rho x}{3\varepsilon_0}$$

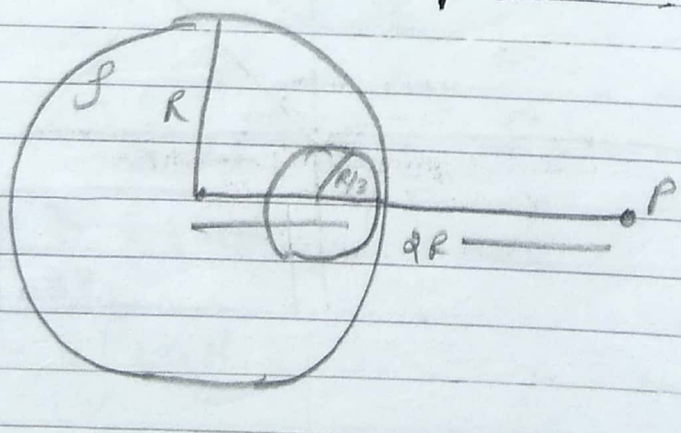
$$a = \left(\frac{q\rho}{3\varepsilon_0 m}\right)x$$

$$a = \omega^2 x$$

$$\omega = \sqrt{\frac{\rho q}{3\varepsilon_0 m}}$$

$$\boxed{T = 2\pi\sqrt{\frac{3\varepsilon_0 m}{\rho q}}}$$

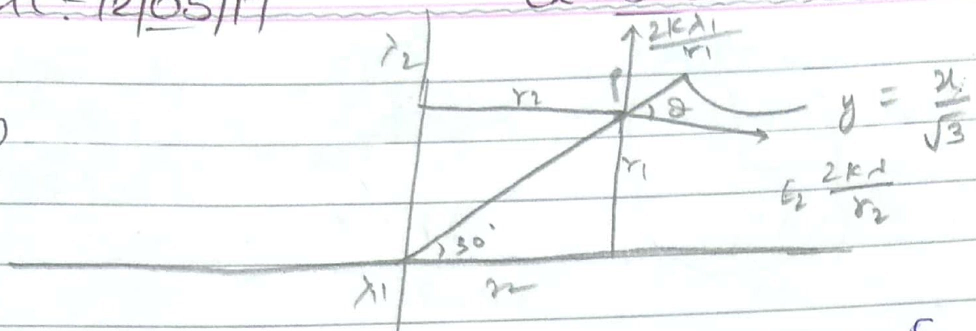
★ Electric field due to a sphere having cavity:



Date: 12/05/17

Ex - S - 2

(4)



$$\tan\theta = \frac{E_1}{E_2}$$

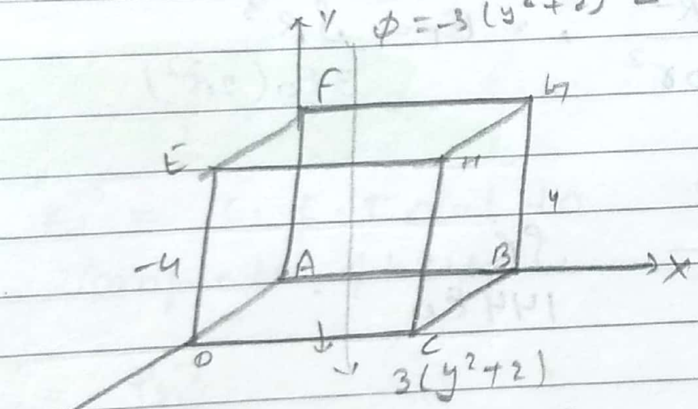
$$\frac{1}{\sqrt{3}} = \frac{\lambda_1 r_2}{\lambda_2 r_1}$$

$$\tan 30^\circ = \frac{r_1}{r_2}$$

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

$\phi = -3(y^2+2) = -q.$

(5)



$3(y^2+2) = 6$

$\phi = 0$

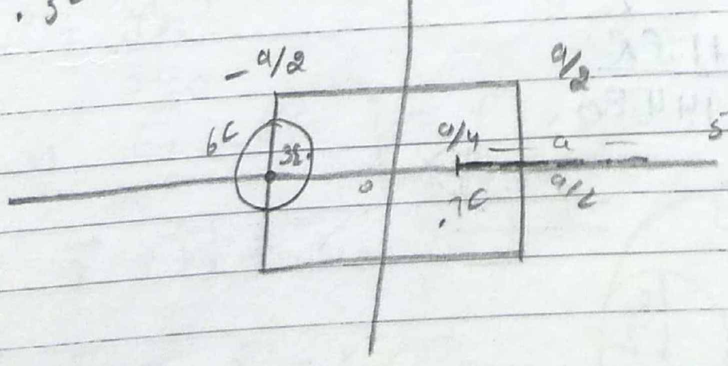
$$-3 = \frac{q_{in}}{\varepsilon_0}$$

$q_{in} = -3\,\varepsilon_0$

$= 3$

Ex: J - A

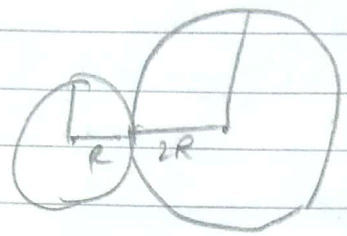
(10)



$= \frac{-2}{\varepsilon_0}$ Ans

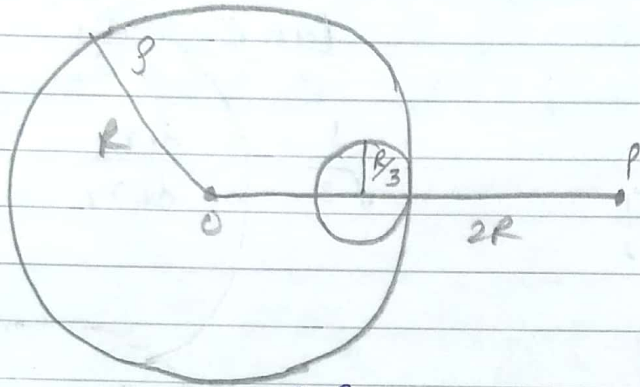
↓ out
↑ in

29



$$\frac{\rho_1 R^3}{3\varepsilon_0 (2R)^2} + \frac{\rho_2 (2R)^3}{3\varepsilon_0 (5R)^2} = 0$$

*



$$E = \frac{\rho R^3}{3\varepsilon_0 r^2}, \quad = E_1 = \frac{\rho R^3}{3\varepsilon_0 (2R)^2}$$

$$E_1 = \frac{\rho R}{12\varepsilon_0}$$

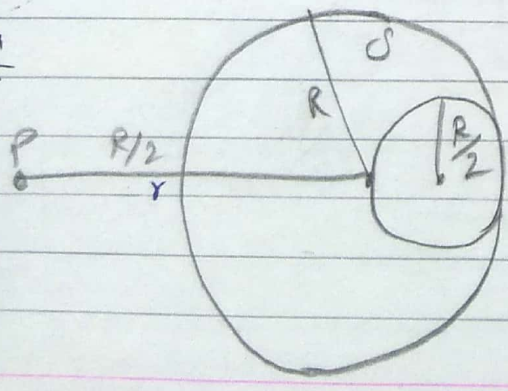
$$E_2 = \frac{\rho (R/3)^3}{3\varepsilon_0 \left(\frac{4R}{3}\right)^2} = \frac{\rho R}{144\varepsilon_0}$$

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

$$= \frac{\rho R}{12\varepsilon_0} - \frac{\rho R}{144\varepsilon_0}$$

$$= \frac{11\rho R}{144\varepsilon_0}.$$

Que:-

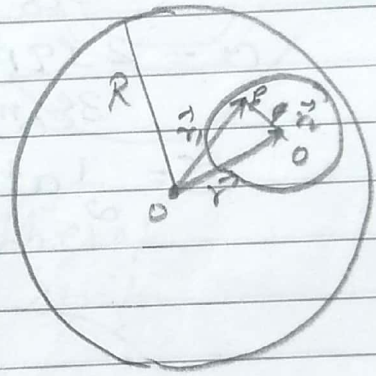


Sol $\Rightarrow$ $E_1 = \dfrac{\rho (R)^3}{3\varepsilon_0 \cancel{r^2} \frac{9}{4}R^2} = \dfrac{4\rho R}{27\varepsilon_0}$

$= \dfrac{\rho \frac{R^3}{8}}{3\varepsilon_0 4R^2} = \dfrac{\rho R}{\varepsilon_0}\left(\dfrac{4}{27} - \dfrac{1}{96}\right)$

$= \dfrac{\rho R}{\varepsilon_0}\Big($

* E.f inside the Cavity :-



$$\vec{E}_{inside} = \frac{\rho \vec{r}}{3\varepsilon_0}$$

$\vec{E_1}$ = E.f.I due to complete sphere.

$$\vec{E_1} = \frac{\rho \vec{r_1}}{3\varepsilon_0}$$

$\vec{E_2}$ = E.f.I due to cavity.

$$\vec{E_2} = \frac{\rho \vec{r_2}}{3\varepsilon_0}$$

$$\vec{E_p} \Rightarrow \vec{E_1} - \vec{E_2} = \frac{\rho}{3\varepsilon_0}(\vec{r_1} - \vec{r_2})$$

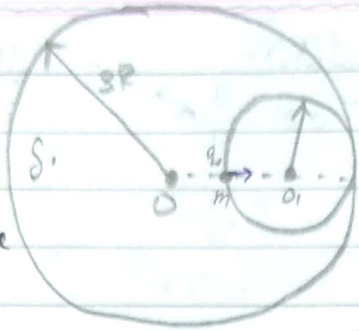
$$\vec{r} + \vec{r_2} = \vec{r_1}$$

$$\vec{r} = \vec{r_1} - \vec{r_2}$$

$$\boxed{E_p = \frac{\rho \vec{r}}{3\varepsilon_0}}$$

$2r =$ Centre to outre.

Ex: A small Particle of mass (m) Charge (q) is placed Just inside the cavity and released after How much time it reach to other End.



$= \cancel{\frac{\rho R^3}{3\varepsilon_0 (3R)^2}}$

$= \cancel{\frac{\rho R^3}{3\varepsilon_0 9R^2}}$

$= \frac{\rho R}{3\varepsilon_0 9} = \frac{\rho R}{27\varepsilon_0}$

Ans:

$$E = \frac{2\rho R}{3\varepsilon_0}$$

$$F = qE$$

$$= \frac{q\,2\rho R}{3\varepsilon_0}$$

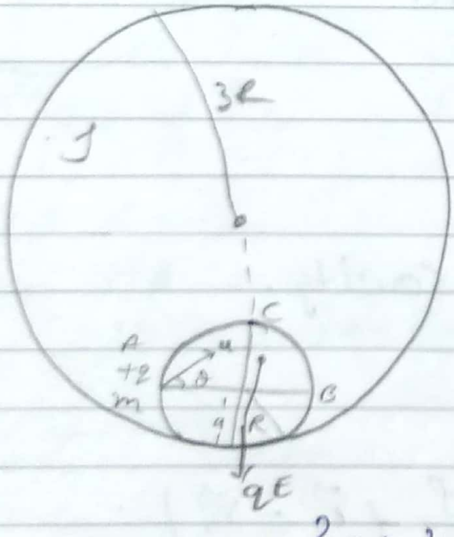
$$a = \frac{2\rho q R}{3\varepsilon_0 m}$$

$v = u + at.$

$v^2 = u^2$

$$S = \frac{1}{2}at^2 \; = \; = \sqrt{\frac{6\varepsilon_0 m}{\rho q}} = t.$$

Ex:



Que: find u so that it touches the surface of the cavity at point C.

mg $\quad a = g$

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

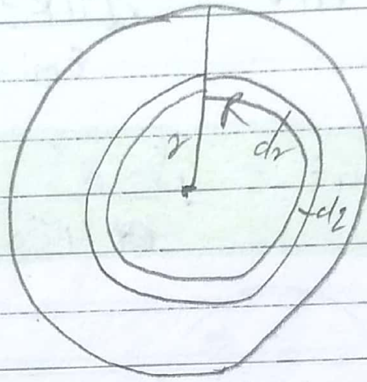
$$y_{max} \Rightarrow R = \frac{u^2 \sin^2\theta}{2\frac{qE}{m}}$$

$H_{max} = \frac{u^2 \sin^2\theta}{2g}$ $T = \frac{2u \sin\theta}{g}$, Range $= \frac{u^2 \sin 2\theta}{g}$

(iii) E.F due to Non-uniformly charge sphere!

$\rho = \frac{\rho_0 r}{R}$ $0 \le r \le R$

$\rho = 0$ $r > R$



ρ_0 = constant

r distt. from centre.

(i) find total charge on sphere!

dv = vol. of spherical strip.

$$dv = 4\pi r^2 dr$$

$$dq = \rho dv$$

$$= \frac{\rho_0 r}{R} 4\pi r^2 dr$$

$$dq = \rho_0 \frac{4\pi}{R} r^3 dr$$

$$q = \frac{\rho_0 4\pi}{R} \int_0^R r^3 dr$$

$$q = \rho_0 \frac{4\pi}{R} \frac{R^{4\,3}}{4}$$

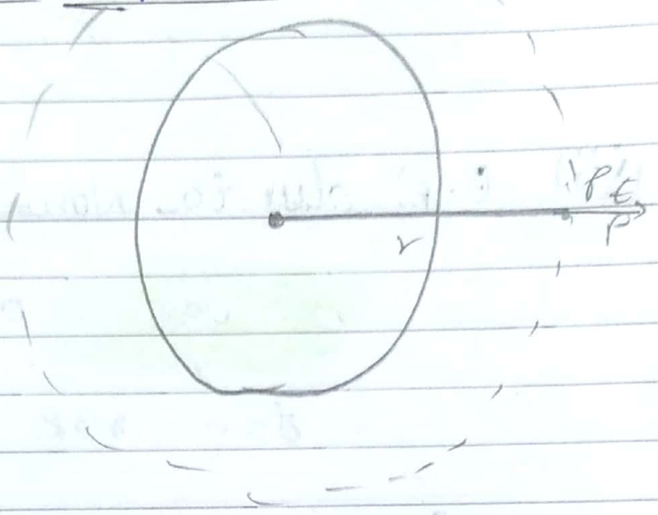
$$q = \rho_0 \pi R^3.$$

))

62✓ $\int r^3 = \frac{r^4}{4}$

[H.W gauss law Ex-Que 1 to 7, 11, ~~18~~ 13, 14]

(ii) E.f intensity outside the sphere : $(r > R)$

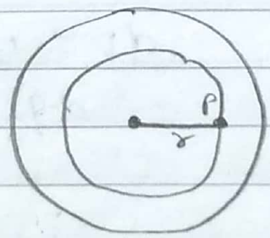


$$\oint E\,dA = \frac{q_{in}}{\varepsilon_0}$$

$$E\,4\pi r^2 = \frac{\rho \pi R^3}{\varepsilon_0}$$

$$\boxed{E_{out} = \frac{\rho_0 R^3}{\cancel{4\pi}\,4\varepsilon_0 r^2}}$$

(ii) Electric field inside the sphere :



$$\oint E\,dA = \frac{q_{in}}{\varepsilon_0}$$

$$E = 4\pi r^2 = \frac{q_{in}}{\varepsilon_0}$$

$$E = \frac{q_{in}}{4\pi\varepsilon_0 r^2}$$

$$dv = 4\pi r^2\,dr$$

$$dq = \rho\,dv = \frac{\rho_0 r}{R}\,4\pi r^2\,dr$$

$$= \frac{\rho_0 4\pi}{R}\int_0^r r^3\,dr$$

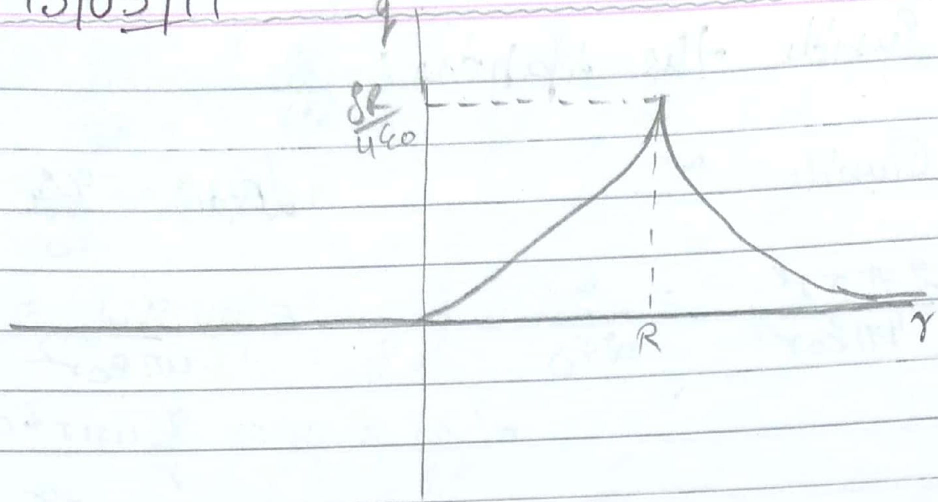
$$q_{in} = \rho_0 \frac{\cancel{4}\pi r^4}{R\,\cancel{4}} = \frac{\rho\pi r^4}{R}$$

$$\boxed{E_{inside} = \frac{\rho_0 \pi r^4}{4\pi\varepsilon_0 r^2 R} \Rightarrow \frac{\rho_0 r^2}{4\varepsilon_0 R}}$$

sphere outside all charge come centre and put formula E.F

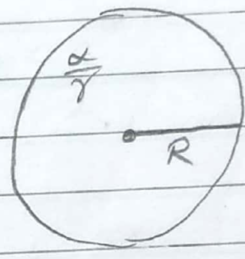
$r = \frac{\alpha r^2}{2}$ $\left[\frac{Kq}{r^2}\right]$

Date: 13/05/17



Que: $\rho = \frac{\alpha}{r}$, Radius $= R$

find total charge on sphere?



Sol^n: $\oint E\,dA =$

$dv = 4\pi r^2 dr$

$dq = \rho\, dv$

$= \frac{\alpha}{r} 4\pi r^2 dr$

i) find electric field outside the sphere.

Ans: $\oint E\,dA = \frac{q_{in}}{\epsilon_0}$

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

$E_{out} = \frac{Kq}{r^2} = \frac{1}{4\pi\epsilon_0} \frac{2\pi\alpha R^2}{r^2}$

$= \frac{\alpha R^2}{2\epsilon_0 r^2}$

Que:

* E.f inside the sphere:

$E_{inside} = \alpha$

$\oint E \cdot dA = \frac{q_{in}}{\varepsilon_0}$

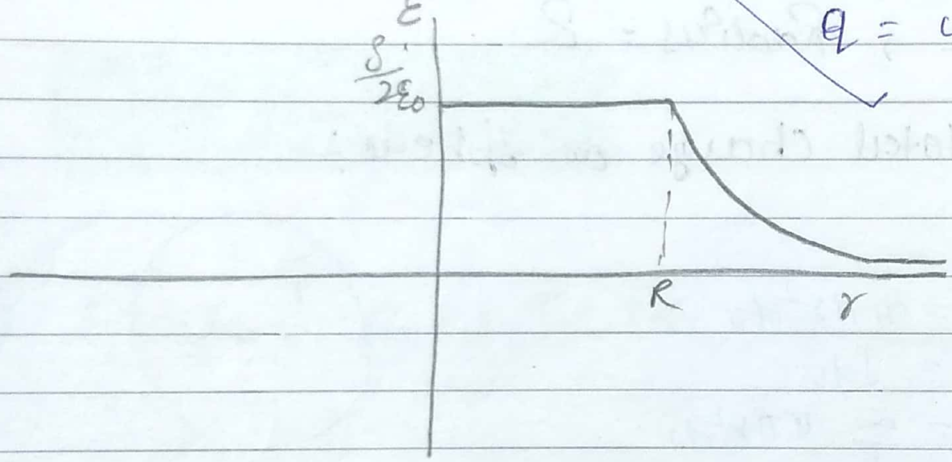
$\frac{2\pi\alpha r^2}{4\pi\varepsilon_0 r^2} = \frac{\alpha}{2\varepsilon_0}$

$E = \frac{q_{in}}{4\pi\varepsilon_0 r^2}$

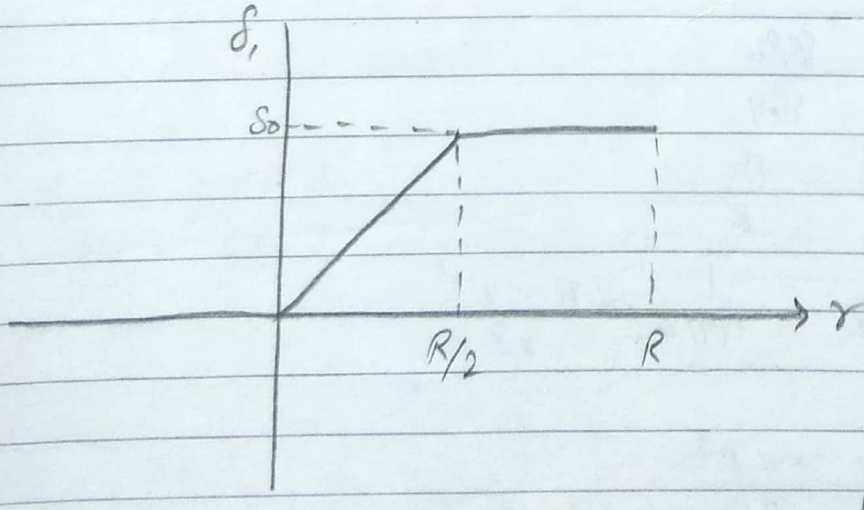
$= \frac{\alpha}{r} 4\pi r^2 dr$

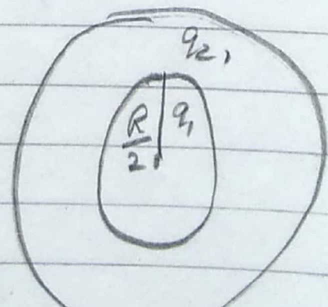
$q = 4\pi\alpha \int_0^r r\,dr$

$= 2\pi\alpha r^2$



Que: charge density inside the sphere is changing as shown as figure.





Find total charge on the sphere.

$dv = 4\pi r_x^2\, dr$. density constant $\Rightarrow$ charge $= \frac{\text{density}}{\text{vol}}$.

slope $-\tan\theta$

origin equation $= \boxed{y = mx}$

Ans: $E_{in} = \frac{\rho r}{3\epsilon_0} = \frac{\rho R}{6\epsilon_0}$ $\quad \rho = \rho_0 \quad \frac{R}{2} < r < R$

$q_2 = \rho_0 \times \text{vol}.$

$= \rho_0 \times \frac{4\pi}{3}\left(R^3 - \frac{R^3}{8}\right)$

$= \rho_0 \times \frac{4\pi}{3} \times \frac{7R^3}{8^2}$

$= \frac{7}{6}\rho_0 \pi R^3$

$y = mx \qquad 0 < r < \frac{R}{2}$

$\rho = \frac{2\rho_0 r}{R}$

$dq = \rho dv$

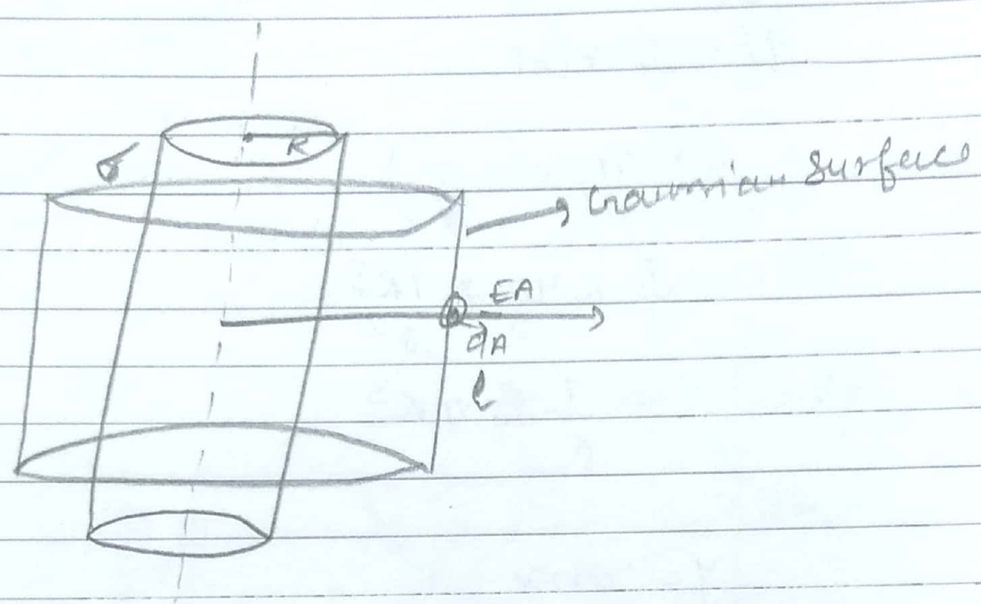
$= \frac{2\rho_0 r}{R} 4\pi r^2 dr$

$= \frac{8\rho_0\pi}{R}\int_0^{R/2} r^3 dr$

$q = \frac{2 \cdot \rho_0\pi}{R}\left(r^4\right)_0^{R/2}$

$q_1 = \frac{\rho_0 \pi R^3}{8}$

* E.f due to a long cylinder :



Hallow cylinder : (i) $r > R$ Outside

$$\int E \cdot dA = \frac{q_{in}}{\epsilon_0}$$

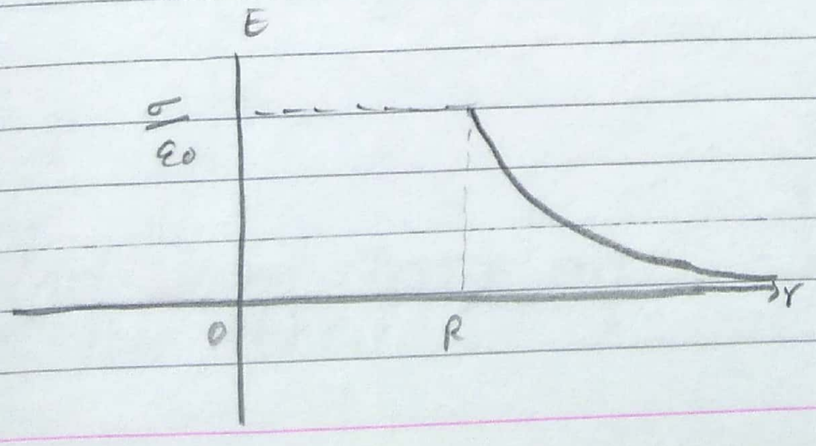
$$E \, 2\pi r R = \frac{\sigma 2\pi R l}{\epsilon_0}$$

$$\boxed{E_{out} = \frac{\sigma R}{\epsilon_0 r}}$$

(ii) Inside $r < R$

$$E dA = \frac{q_{in}}{\epsilon_0} \quad , \quad E dA = 0$$

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



(2) Solid cylinder :

Fig. same as 1st but charge ρ (vol.)

(i) $r > R$ Outside:

$$\oint E\,dA = \frac{q_{in}}{\varepsilon_0}$$

$$E \cdot 2\pi r l = \frac{\rho \pi R^2 l}{\varepsilon_0}$$

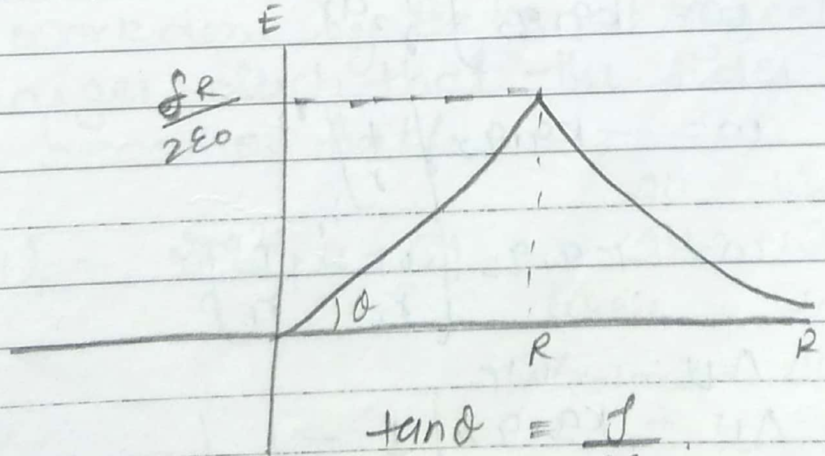
$$\boxed{E_{out} = \frac{\rho R^2}{2\varepsilon_0 r}}$$

(ii) Inside the cylinder : $r < R$:

$$E\oint dA = \frac{q_{inside}}{\varepsilon_0}$$

$$E\, 2\pi r l = \frac{\rho \pi r^2 l}{\varepsilon_0}$$

$$\boxed{E_{inside} = \frac{\rho r}{2\varepsilon_0}}$$



$$\tan\theta = \frac{\rho}{2\varepsilon_0}$$

$\int \frac{1}{r} \Rightarrow \left[\frac{1}{r}\right]$

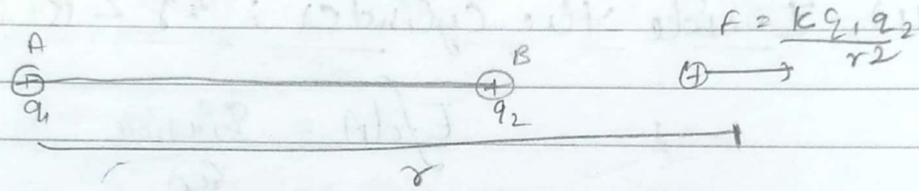
Potential & not calculated

physical quantity → measure

Electrostatics Potential Energy (ΔU):

1) It is defined for a system
2) It is define only for conservated forces.
3) Potential energy is not absolutely define only change in potential energy defined.

$\Delta U = -W_c$



Potential Energy of two point charge:

$$W = \int F \cdot dr$$

$$W = kq_1q_2 \int \frac{1}{r^2} dr$$

$$W = -kq_1q_2 \left[\frac{1}{r}\right]_{r_1}^{r_2}$$

$$W = -kq_1q_2 \left[\frac{1}{r_2} - \frac{1}{r_1}\right]$$

$$\Delta U = -W_c$$

$$\Delta U = kq_1q_2 \left[\frac{1}{r_2} - \frac{1}{r_1}\right]$$

$$U_f - U_i = kq_1q_2 \left[\frac{1}{r_2} - \frac{1}{r_1}\right]$$

$r_1 = r_0$ $\quad$ $r_2 = \infty$

$U_i = U_0$ $\quad$ $U_f = 0$

$$0 - U_0 = kq_1q_2 \left[\frac{1}{\infty} - \frac{1}{r_0}\right]$$

H.W - Race-6

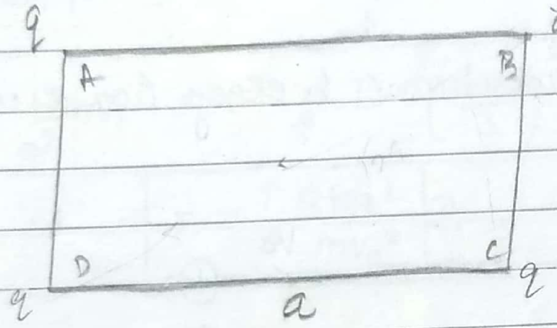
Sheet { Ex-S-1 Que:-6
Ex-O-1, ⇒ 84, 89, 90, 92, 94, 108, 109
Ex-O-2, ⇒ 5, 6, 7, 8, 9,

$$+V_0 = +\frac{kq_1q_2}{r_0}$$

$$\boxed{U = \frac{kq_1q_2}{r_0}}$$

Date: 15/05/17

Que: (i)



* find potential energy of the system.

Ans: $U = \frac{kq^2}{a} + \frac{kq^2}{\sqrt{2}a} + \frac{kq^2}{a} + \frac{kq^2}{a} + \frac{kq^2}{\sqrt{2}a} + \frac{kq^2}{a}$ Ans

$U = \frac{4kq^2}{a} + \frac{2kq^2}{\sqrt{2}a} \Rightarrow U = \frac{kq^2}{a}(4+\sqrt{2})$.

(ii) find work done by External agent to move the charges. such that the sides of square becomes half.

Ans: $U_f = \frac{2kq^2}{a}(4+\sqrt{2})$

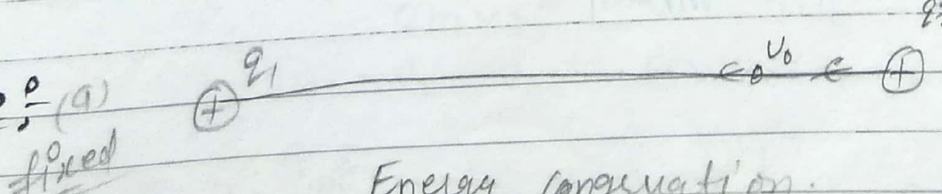
$\Delta U = -W_c$

$\Delta U = -W_{ext.}$

$W_{elect} = -\Delta U$

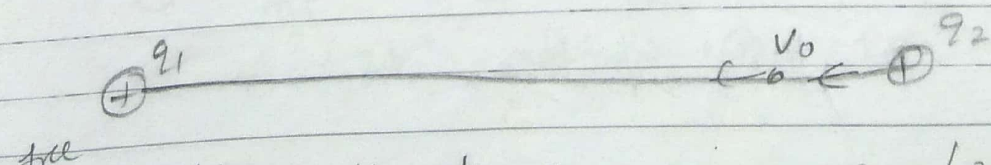
$W_{external} = \Delta U$.

Note: (a)



Energy conservation.

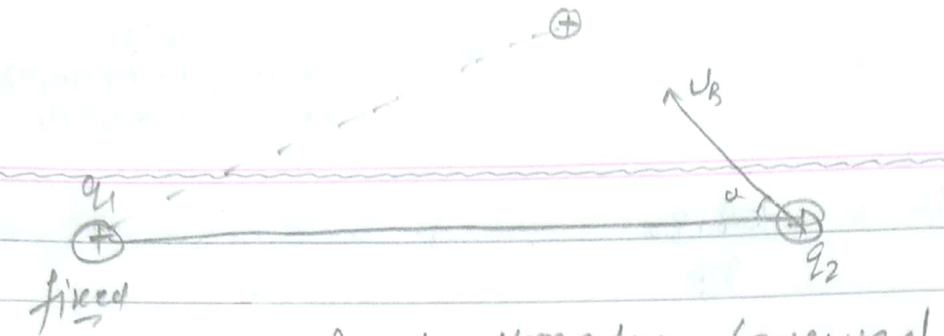
(b)



Linear Momentum / Energy { conservation }

L.M.C + E.C

(C)

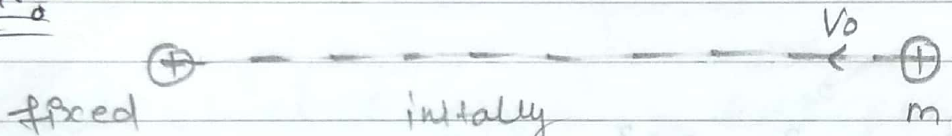


Angular Momentum Conserved
Energy Conserved

(d)

Linear Momentum, Angular Momentum or Energy Conserved.

Ex:-



initially at large distance

Find distance of closest approach.

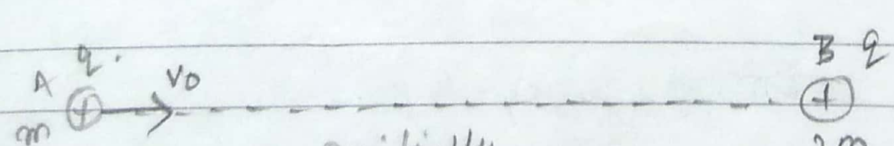
Ans:

$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2}mv_0^2 + 0 = 0 + \frac{kq^2}{r}$$

$$\boxed{r = \frac{2kq^2}{mv^2}}$$

Ex:-



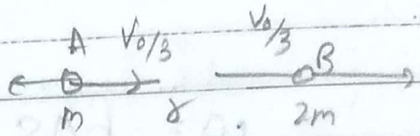
initially at large separation

Ans: i) find minimum sepration b/w A and B.

Ans: At minimum sepration both A and B will have same velocity.

$$3mv = mv_0$$

$$v = \frac{v_0}{3}$$



(ii) $K_i + U_i = K_f + U_f$

$$\frac{1}{2}mv_1^2 + 0 = \frac{1}{2}3m\left(\frac{v_0}{3}\right)^2 + \frac{kq^2}{r}$$

$$\boxed{r = \frac{3kq^2}{mv_0^2}}$$ Ans

iii) find sepration b/w A and B when A comes to rest.?

Ans:

$$2mv = mv_0$$

$$v = \frac{v_0}{2}$$

→ initial kinetic (K_i)
initial Potential (U_i)

$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2}mv_0^2 + 0 = \frac{1}{2}2m\cdot\left(\frac{v_0}{2}\right)^2 + \frac{kq^2}{r}$$

iv) find velocity of A and B when sepration again becomes large.

Momentum-vector

Ans:

$$2mv_2 - mv_1 = mv_0$$

$$2v_2 - v_1 = v_0 \quad \text{—(1)}$$

$$\frac{1}{2}mv_0^2 + 0 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 + 0$$

$$v_1^2 + 2v_2^2 = v_1^2 \quad \text{—(2)}$$

Date: 16/05/17

* Work done by a force :

$$w = \vec{f} \cdot \Delta\vec{s} \quad \text{(force constant)}$$

$$= \int \vec{f} \cdot d\vec{s} \quad \text{(force variable).}$$

$$w = f \Delta s \cos\theta$$

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

$A(1,0,2) \qquad B(-2,3,4)$

find work done by the force.

Ans:

$$\Delta\vec{S} = -3\hat{i} + 3\hat{j} + 2\hat{k}$$

$$= -6 + 9 - 2 = 1\,J. \text{ Ans.}$$

(ii) $F = x\hat{i} + y^2\hat{j}$

$A(1,2)$ to $B(2,1)$

Ans:

$$d\vec{s} = dx\hat{i} + dy\hat{j}$$

$$w = \int \vec{F} \cdot d\vec{s}$$

$$= \int_1^2 x\,dx + \int_2^1 y^2\,dy$$

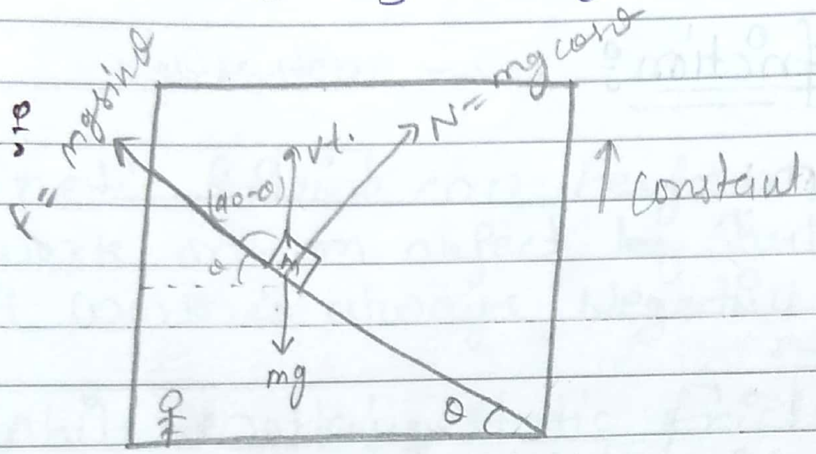
$$= \left[\frac{x^2}{2}\right]_1^2 + \left[\frac{y^3}{3}\right]_2^1$$

Kx - Spri'n

$$\frac{3}{2} + \left(\frac{1^3 - 2^3}{3}\right)$$

$$\frac{3}{2} - \frac{7}{3} \quad \frac{9-14}{6} = \frac{-5}{6} \text{ Ans}$$

Que:



A: Block is at rest with respect to lift. Find work done by each force acting on the block in time t. from ground frame.

Ans:

$$W_{gra.} = -mgvt.$$

$$W_{friction} = fS\cos(90-\theta)$$
$$= mg\sin\theta vt\sin\theta$$
$$= mgvt\sin^2\theta$$

$$W_{Normal} = Nvt\cos\theta$$
$$= mgvt\cos^2\theta$$

$$(W_{total})_A = 0 \text{ Ans}$$

(ii) Find work done by each force acc to B

observer $s=0$

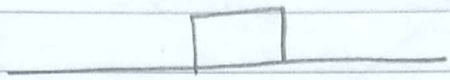
$W_g = 0$ $\quad$ $W_N = 0$

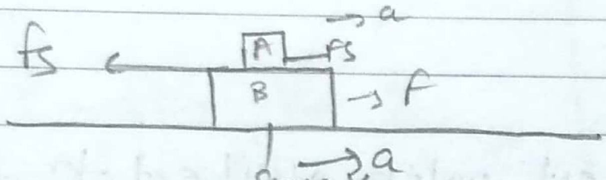
$W_f = 0$ $\quad$ $W_{total} = 0$

* work done by a force depends on frame of reference but total workdone is independent of frame of refrence.

* **Work done by friction:**

i) Static friction:





$W_A = f_s \cdot s$

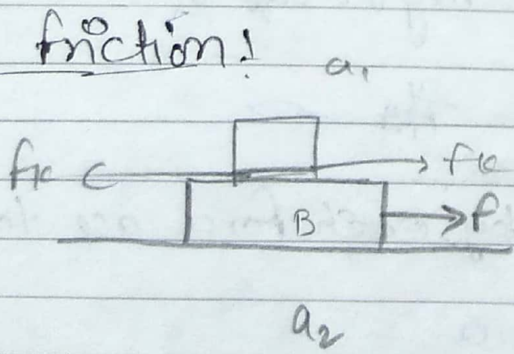
$W_B = -f_s \cdot s$

$W_{system} = 0$

Energy loss
Energy conserved

* Static friction can perform positive, negative and zero work on an object but on a system is work is always zero.

(ii) Kinetic friction:



$a_2 > a_1$

K-(-ve)

$W_A = f_k \frac{1}{2} a_1 t^2$ $\qquad S_A = \frac{1}{2} a_1 t^2$

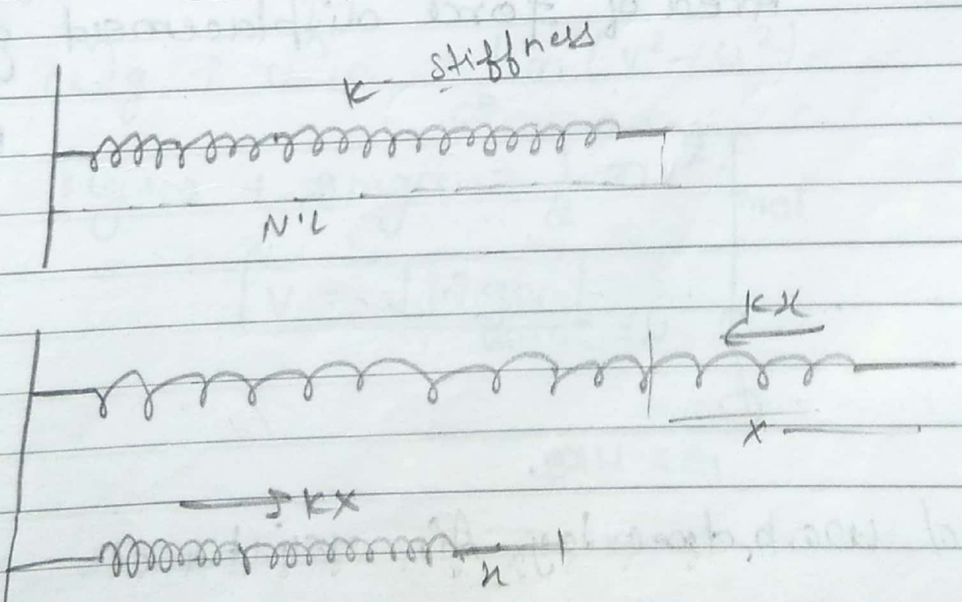
$W_B = - f_k \frac{1}{2} a_2 t^2$ $\qquad S_B = \frac{1}{2} a_2 t^2$

$W_{system} = -ve.$ $\qquad (a_2 > a_1)$

* Kinetic friction can Perform Positive or negative work on an object ~~log~~ but on a system it work is always Negative.

* while working static friction at on a mem in the direction of Motion. and its work done is zero.

* Work done by Spring:-



$W = f dx$

$= -K \int_{x_1}^{x_2} x \, dx$

$$w = \frac{1}{2}k(x_2^2 - x_1^2)$$

$x_1 = 0$ $\quad$ $x_2 = x$

$$\boxed{w_{sp} = -\frac{1}{2}kx^2}$$

* Work Energy theorm:

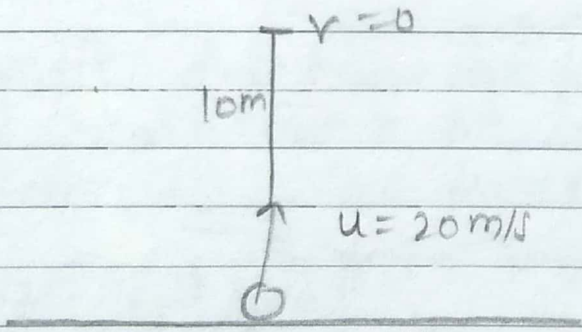
$$\boxed{W_{all} = \Delta KE}$$

$$\boxed{W_{all} = \frac{1}{2}m(v^2 - u^2)}$$

= Area of force displacement graph.

Que:

$\cancel{H_{max} = \frac{u^2}{2g}}$



m = 4kg.

Find work done by Air resistance

Ans:

$= \cancel{\frac{1}{2}m(v^2 - u^2)}$

$W_{all} = \Delta KE$

J.M ⇒ Q.6, 7, 8, 10, 11, 12, 15, 17, 19, 24.

$W_g + W_{air} = KE_f - KE_i$

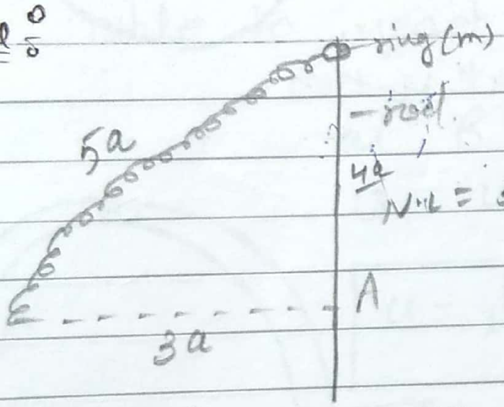
$-400 + W_{air} = 0 - \frac{1}{2} 4 \times (20)^2$

$W_{air} = -\frac{1}{2} 4 \times (20)^2 = \frac{1}{2} \times 4 \times 400$

$W_{air} = -400 \quad = -800 + 400$

$= -400$ Ans

Que:



find speed of the spring at A

Spring force (K) = $\frac{mg}{a}$

$W_{sp} = -\frac{1}{2} K (x_f^2 - x_i^2)$

$= -\frac{1}{2} \times \frac{mg}{a} (0 - (2a)^2)$

$= \frac{1}{2} \frac{mg}{a} 4a^2 = 2mga$

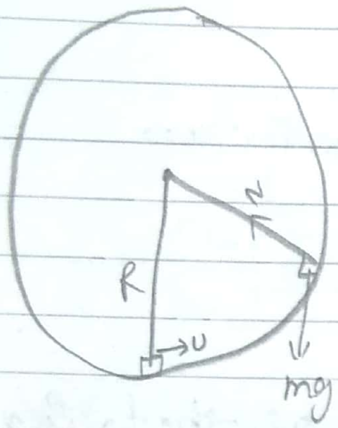
Ans: $W_g + W_{sp} = \frac{1}{2} m (v^2 - u^2)$

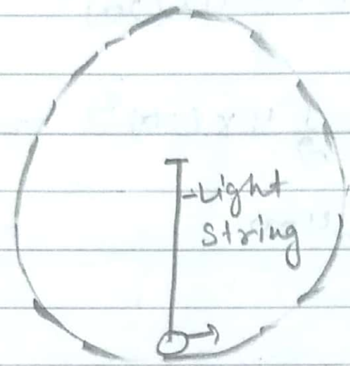
$mg\,4a + 2mga = \frac{1}{2} m v^2.$

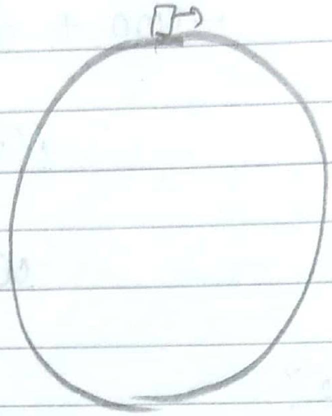
$\boxed{v = \sqrt{12ga}}$

Date: 17/05/17

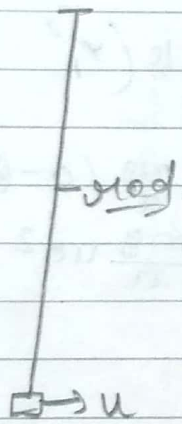
* Vertical circular motion:



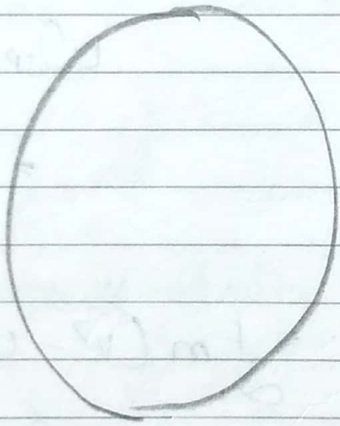


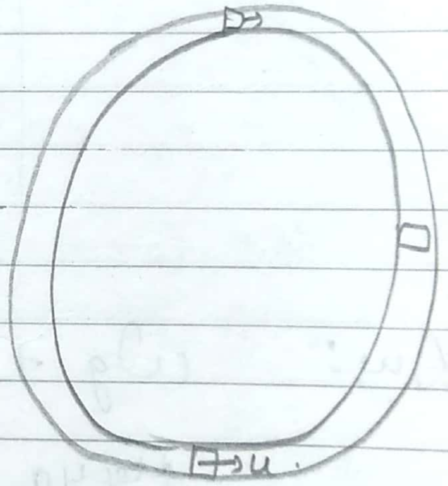


$u = \sqrt{5gR}$ May Break Motion



$u = \sqrt{4gR}$





Not Break Motion.

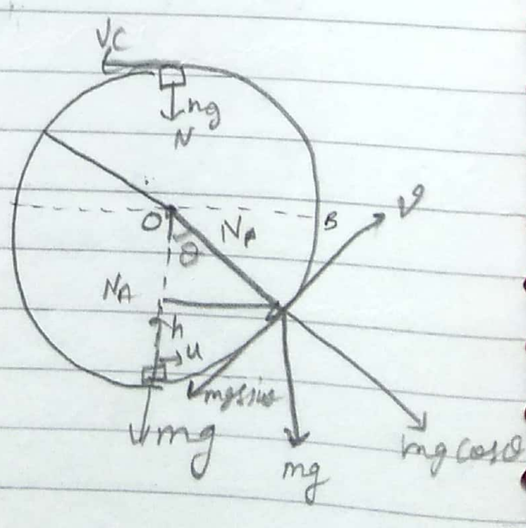
*

$$N_A - mg = \frac{mu^2}{R} \quad \text{—(i)}$$

at Point P

$$\cancel{at} = a_t = -g \sin\theta$$

$$N - mg\cos\theta = \frac{mv^2}{R} \quad \text{—(ii)}$$



$$-mgh = \frac{1}{2}m(v^2-u^2)$$

$$-2gh = v^2 - u^2$$

$$v^2 = u^2 - 2gh \quad \text{—(iii)}$$

$$h = R(1-\cos\theta) \quad \text{—(iv)}$$

Case :- I : minimum initial speed so that block is able to reach at B.

at B , $v = 0$

$$0 = u^2 - 2gh$$

$$\boxed{u = \sqrt{2gR}}$$

If $u \leq \sqrt{2gR}$
then object perform oscillatory motion in lower half of the circle.

Case II :- minimum initial speed so that block can complete circular motion.
To complete circular motion normal reaction at higher point becomes zero.

at C $\quad N = 0$

$$N + mg = \frac{mv_c^2}{R}$$

$$mg = \frac{mv_c^2}{R}$$

$$V_c = \sqrt{gR}$$

$$V_c^2 = u^2 - 2gh$$

$$gR = u^2 - 4gR$$

$$\boxed{u = \sqrt{5gR}}$$

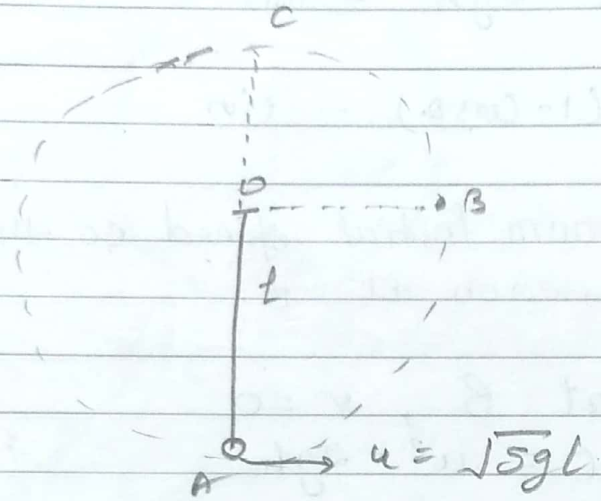
Relation initial and final → $v^2 = u^2 - 2gh$

centripetal? tangential?

Case: III: $\sqrt{2gR} < u < \sqrt{5gR}$

then it leave contact before highest point and move like a projectile ~~mo~~.

Que:



* find acc. of object at B

Sol:

$a_c = \frac{v^2}{R} = \frac{v^2}{l} = 3g$

$a_t = -g\sin\theta = -g$

$v^2 = u^2 - 2gh$

$v^2 = 5gl - 2gl$

$v^2 = 3gl$

$\frac{v^2}{l} = 3g$

$a = g\sqrt{10}$

Find tension in the string at B.

$$T = \frac{mv^2}{R} = 3mg.$$

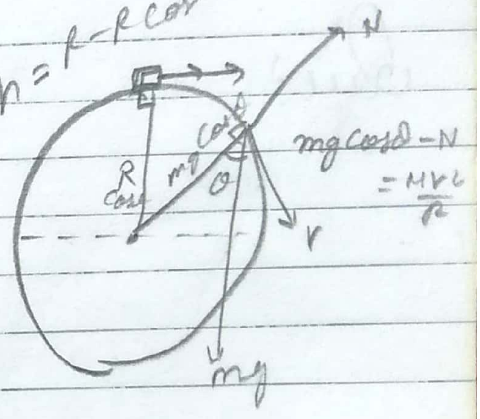
* find $T_{max.}$ and $T_{minimum}$:-

$$T_{max} = T - mg = \frac{mv^2}{R}$$

$$T = \frac{mv^2}{R} + mg.$$

$$T_{max.} = m(g + 5g) = 6mg \text{ Ans}$$

Que:- find speed of block when it leave contact.



Ans:- mgh

$$mg\cos\theta - N = \frac{mv^2}{R}$$

$$Mg\cos\theta = \frac{mv^2}{R}$$

$$v = \sqrt{Rg\cos\theta}$$

$$mgh = \frac{1}{2}m(v^2 - u^2)$$

$$2gh = v^2 - u^2$$

$$v^2 = u^2 + 2gh$$

$$v = \sqrt{2gh}.$$

$$v = \sqrt{2gR(1-\cos\theta}$$

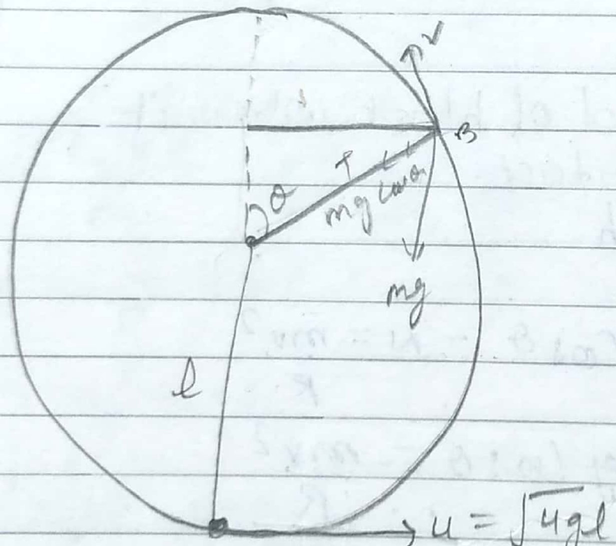
$$2gR(1-\cos\theta) = Rg\cos\theta$$

$$2 - 2\cos\theta = \cos\theta$$

$$\cos\theta = 2/3$$

$$\theta = \cos^{-1}\left(\frac{2}{3}\right)$$

Que:-



* Find max. height attained by the ball.

Ans:-

$\cancel{v^2} = \cancel{u^2} - \cancel{2gh}$

$\cancel{0} = \cancel{4gl} - \cancel{2gh}$

$\cancel{2l} = \cancel{2h}$

$$T + mg\cos\theta = \frac{mv^2}{l}$$

$$v^2 = u^2 - 2gh$$

$$v^2 = 4gl - 2gl(1+\cos\theta)$$

$$v^2 = 4gl - 2gl(1+\cos\theta)$$

Imp (47)

$$v^2 = 2gl(1-\cos\theta)$$

Let $T = 0$

$$\cancel{m}g\cos\theta = \frac{\cancel{m}v^2}{l}$$

$$g\cos\theta = \frac{2gl}{l}(1-\cos\theta)$$

$$\cos\theta = 2 - 2\cos\theta$$

$$\boxed{\cos\theta = \frac{2}{3}}$$

$$h_{max} = \frac{v^2\sin^2\theta}{2g}$$

$$= \frac{\cancel{2g}\,l}{3\times \cancel{2g}} \times \frac{5}{9}$$

$$= \frac{5l}{27}$$

$$h_{total} = h + h_{max}$$

$$= \frac{5l}{3} + \frac{5l}{27}$$

$$= \frac{50\,l}{27}$$

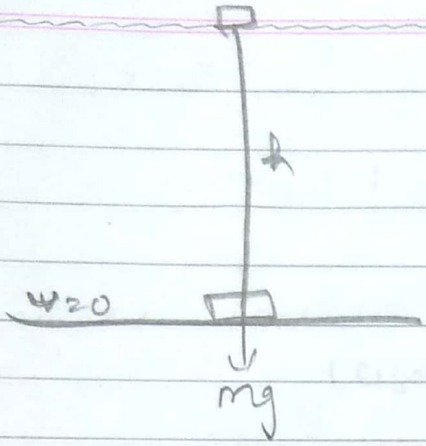
* Potential Energy :

$$\Delta U = -W_c$$

G.P.E :

spring P.E not use

H.W:- S-1 ⇒ 8, 9, 10, 13,
S-2 ⇒ 2, 11, 7
O-2 ⇒ 29,



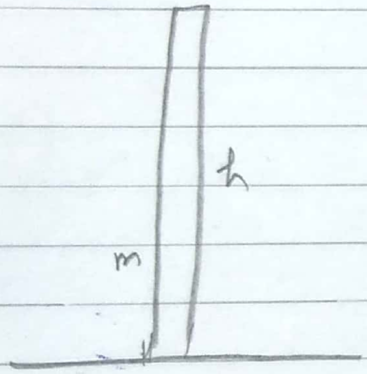
$$W_g = -mgh$$

$$\Delta U = -W_g$$

$$\Delta U = mgh$$

$$U_f - U_i = mgh$$

$$\boxed{U_f = mgh}$$



$$U = mgh/2$$

$$= mgh_{cm}$$

* Elastic P.E

P.E of Spring: $\boxed{U = \frac{1}{2} kx^2}$

N.L $\quad U = 0$

(Natural length).

Heighest point $= 0$

non-conducting $\frac{\sigma}{2\varepsilon_0}$

Date: 18/05/17 S-1

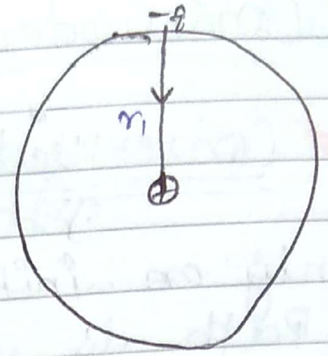
(8) Qu!

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

$$K = \frac{1}{2}mv^2 = \frac{KQq}{2r}$$

$$U = -\frac{KQq}{r}$$

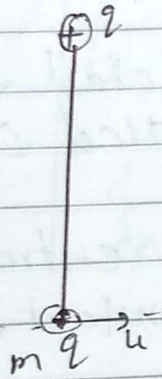
$$E_1 = \frac{-KQq}{2r_1}$$



$$E_2 = -\frac{KQq}{2r_2}$$

$$W = E_2 - E_1$$

(9)



$$T + mg - \frac{Kq^2}{l^2} = \frac{mv^2}{u}$$

$T = 0$

$$10 - \frac{9\times10^9 \times 1600\times10^{-12}}{}$$

* Conservated and non conservated force :

1) **Conservated force** : Its work done is independent of path. it depends only on initial and final position in a closed Path is work is always zero.

mg, kx, F_{ex} $\Rightarrow$ Conservated.

* All the central force are conservated

Central force :

All the forces which are directed towards or away from a fixed point. Called central force.

$$\vec{F} = F_0 \hat{r} \quad \text{— Called central force}$$
$$= \alpha \hat{r} \quad (F_0 \text{ constant})$$

For Ex: $F = \dfrac{18(x\hat{i} + y\hat{j} + z\hat{k})}{(x^2+y^2+z^2)^{5/2}}$

$$= \frac{18(x\hat{i} + y\hat{j} + z\hat{k})}{(x^2+y^2+z^2)^2 (x^2+y^2-z^2)^{1/2}}$$

$$F = \frac{18}{k^2}\hat{r}$$

Check conservated force $\Rightarrow$ $\boxed{\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}}$

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ f_x & f_y & f_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \end{vmatrix} = 0$$ Conservated force

<u>Ex:</u> $f = f_x\hat{i} + f_y\hat{j}$

check:

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ f_x & f_y & 0 \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \end{vmatrix} = \hat{k}\left(\frac{\partial f_x}{\partial y} - \frac{\partial f_y}{\partial x}\right) = 0$$

$$\boxed{\frac{\partial f_x}{\partial y} = \frac{\partial f_y}{\partial x}}$$

$\vec{F} = x\hat{i} + y\hat{j}$

$f_x = x$

$\frac{\partial f_x}{\partial y} = 0$

$f_y = y$

$\frac{\partial f_y}{\partial x} = 0$

$\vec{F} = 2\hat{i} + 3\hat{j} + 5\vec{k}$

Conservation f

~~All cons~~ alluoay Conserv

Constant always Conservat

$\hat{i}$ માં આવે x $\hat{j}$ માં આવે y force હોય તો conservated હોય,

(2) $\vec{F} = x^2\hat{i} + y\hat{j}$

$0 = 0$

differeni! $x^n = nx^{n-1}$ $\quad n^x$

Ex! $f = y\hat{i} + x\hat{j}$

$f_x = y$ $\quad f_y = x$

$\frac{\partial f_x}{\partial y} = 1$ $\quad \frac{\partial f_y}{\partial x} = 1$ $\quad$ Conservated Force

Ex! $f = y^2\hat{i} + x^2\hat{j}$

Non Conservated force

Ex! $\vec{f} = y\hat{i} + x\hat{j}$

Non Conservated.

$-1 = 1$

Ex! $\vec{f} = xy\hat{i} + x\hat{j}$.

$\frac{\partial(xy)}{\partial y}$ $\quad$ (Non-Conservated)

Ex! $\vec{f} = 2xy\hat{i} + x^2\hat{j}$ $\quad$ (Conservated)

$2x - 2x$

$\hat{i} = y$ Respect

$\hat{j} = x$

Que: $y^2\hat{i} - 2xy\hat{j}$ $\quad$ Non Conservated.

$W_{int} \to$ Conv + Non-c

Result

* Energy Conservation :

* Conservation of Mechanical Energy :

Work energy theorm :

$$W_{all} = \Delta KE$$
$$W_{int} + W_{ext} = \Delta KE$$
$$W_C + W_{NC} + W_{ext} = \Delta KE$$
$$-\Delta U + W_{NC} + W_{ext} = \Delta K$$
$$\boxed{\Delta U = -W_C}$$
$$W_{NC} + W_{ext} = \Delta K + \Delta U$$
$$= \Delta ME$$
$$= \Delta E$$

$$\boxed{W_{NC} + W_{ext} = E_f - E_i}$$

If W_{NC} & $W_{ext} = 0$

then

$$E_i = E_f$$
$$K_i + U_i = K_f + U_f$$

(i) There is no ext. force

$$W_{ext} = 0$$
$$W_{NC} = E_f - E_i$$

ii) if N.C is static friction.

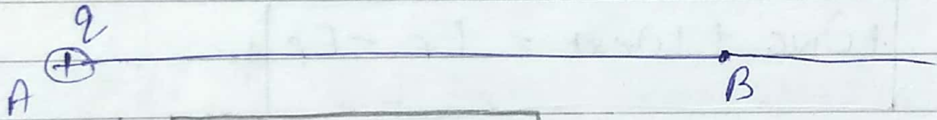
$$W_{NC} = 0$$
$$E_f = E_i$$

If NC is kinetic friction.
E.C Not applicable.

Electric Potential (V) : unit → Volt

Electric Potential is not absolutely define only change in Potential ~~define~~ energy define. or Potential difference is define.

Potential difference b/w two Points is the work done by External agent to take a unit positive charge slowly from initial to final point.



$$\boxed{\Delta V = \frac{W_{ext.}}{q}}$$

$$V_B - V_A = \frac{W_{ext}}{q} = \frac{\Delta U}{q} = -\frac{W_{electrostatic\ force}}{q}$$

Formula

$W_{ext.} = q\Delta V$

$\Delta U = q\Delta V$

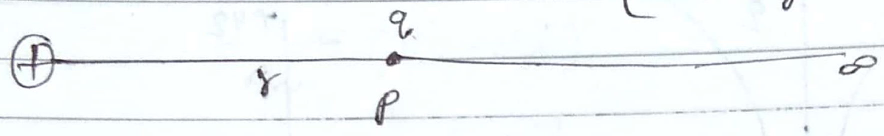
$W_{elect.} = -q\Delta U$

{ H.W: Race: 8,
Ex: J.A ⇒ 4, 7, 8, 9, 13, 24, 30, 31, 32, 36 }

* Electric Potential due to a point charge:

Scalar

{ at infinity Potential due to point charge = 0 }



$$\Delta V = \frac{\Delta U}{q} = \frac{U_f - U_i}{q} = \frac{0 - KQ\cancel{q}/r}{\cancel{q}}$$

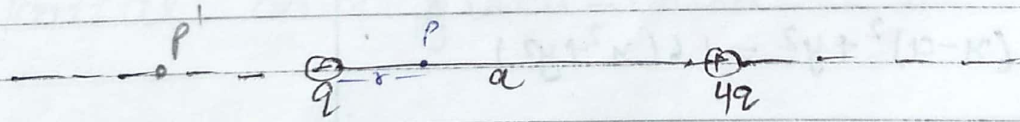
$$\Delta V = \frac{-KQ}{r}$$

$$V_\infty - V_P = -\frac{KQ}{r}$$

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

Date: 22/05/17

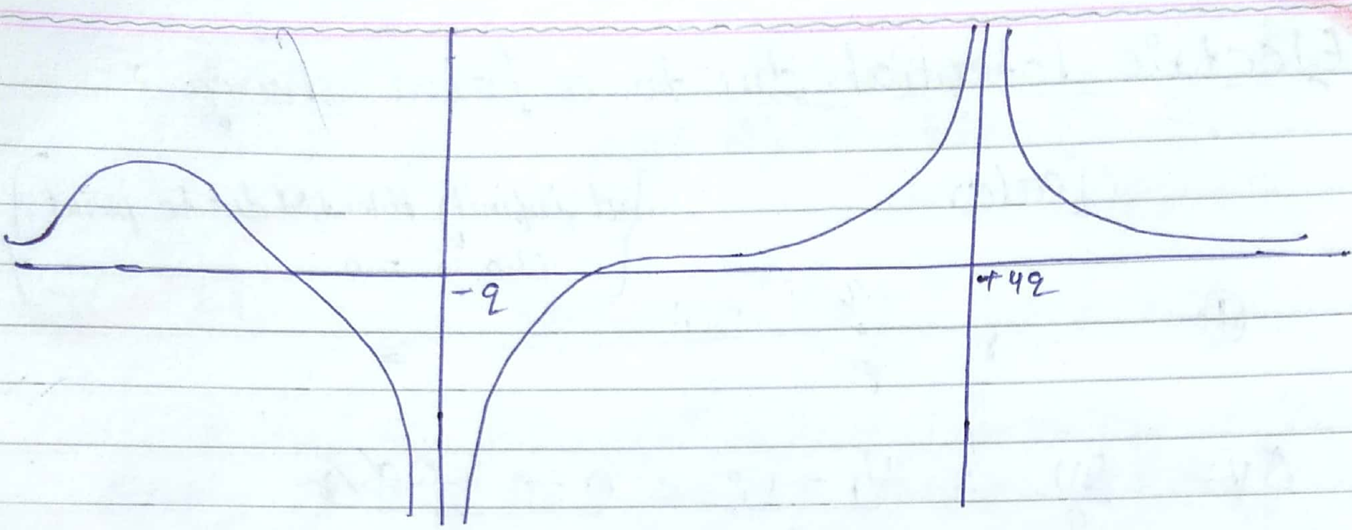
Que:



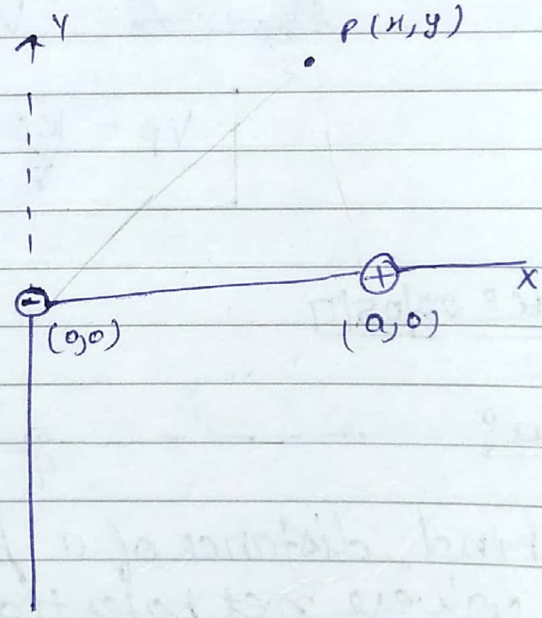
Find distance of a point on line of joining where net potential is zero. from smaller charge.

Ans: $P_1 = \frac{-kq}{r} + \frac{k \cdot 4q}{(r-a)} = 0$

$P' = \frac{-kq}{r} + \frac{4kq}{r+a} = 0 \Rightarrow r = \frac{a}{3}$



(iii) find Locus of all the points in xy plane where potential is zero.



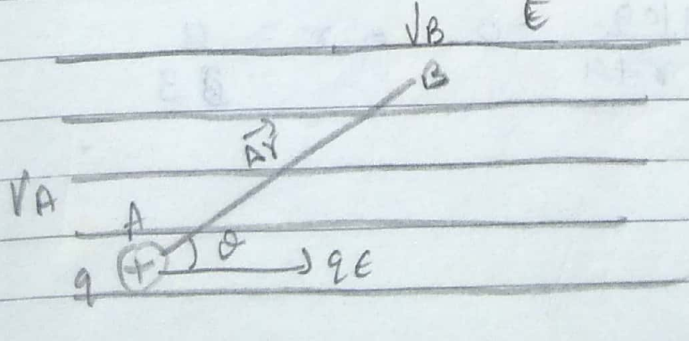
$$= \frac{-kq}{\sqrt{x^2+y^2}} + \frac{4kq}{\sqrt{(x-a)^2+y^2}}$$

$$= \frac{1}{\sqrt{x^2+y^2}} = \frac{4}{\sqrt{(x-a)^2+y^2}}$$

$$= (x-a)^2+y^2 = 16(x^2+y^2)$$

$$= 15x^2+15y^2+2ax-a^2=0$$

* Relation b/w Electric Field and Potential :



$W_{elect.} = qE\,\Delta r \cos\theta$
$= q\vec{E}\cdot \Delta r$

$W_{elect.} \Rightarrow -q\,\Delta V$
$= -q\,(V_B - V_A)$

$-q\,\Delta V = q\vec{E}\cdot\Delta\vec{r}$

$\Delta V = -\vec{E}\cdot\Delta\vec{r}$ ⇒ when $\vec{E}$ is constant

$\Delta V = -\int \vec{E}\cdot d\vec{r}$ ⇒ when $\vec{E}$ is variable

* Negative sign indicate that potential decreases in the direction of field

* If a positive charge is released in electric field it move from high potential to low potential. and vica-versa.

Que: $\vec{E} = E_0\hat{i} - 2E_0\hat{j}$.
P.d b/w A (-1, 2) & B (2, 3).

Sol: $\Delta\vec{r} = 3\hat{i} + \hat{j}$

$\Delta V = -(\vec{E}\cdot\Delta\vec{r})$

$= -(3E_0 - 2E_0)$

$= -E_0$

$E = -A$

(ii) find work done by external agent to take a charge q from A to B.

Ans
$$W_{ext} = q\Delta V$$
$$= -q\varepsilon_0$$

Que: $\vec{E} = 2x\hat{i} + y\hat{j}$
find Potential difference b/w A(-1, -1) and B (1, 1)

Ans:
$$d\vec{r} = dx\hat{i} + dy\hat{j}$$
$$\Delta V = -\int \vec{E} \cdot dr$$
$$= -\left[\int_{-1}^{1} 2x\,dx + \int_{-1}^{1} y\,dy\right]$$
$$\Delta V = -\left[(x^2)_{-1}^{1} + \frac{1}{2}\left[y^2\right]_{-1}^{1}\right]$$
$$\Delta V = 0$$

(ii)
$$\Delta V = -E\Delta r$$
$$E = -\frac{\Delta V}{\Delta r}$$
$$E = -\frac{dv}{dr}$$
$$V = f(x, y, z)$$
$$E_x = -\frac{\partial V}{\partial x}\Big/ y, z - \text{Constant}$$

$$E_y = -\frac{\partial v}{\partial y} \Big/ x, z \text{ constant}$$

$$E_z = -\frac{\partial v}{\partial z} \Big/ x, y \text{ constant.}$$

$$\vec{E} = E_x\hat{i} + E_y\hat{j} + E_z\hat{k}.$$

Que: $v = 2xy$ find Electric field.

$$E_x = -\frac{\partial v}{\partial x} = -2y$$

$$E_y = -\frac{\partial v}{\partial y} = -2x$$

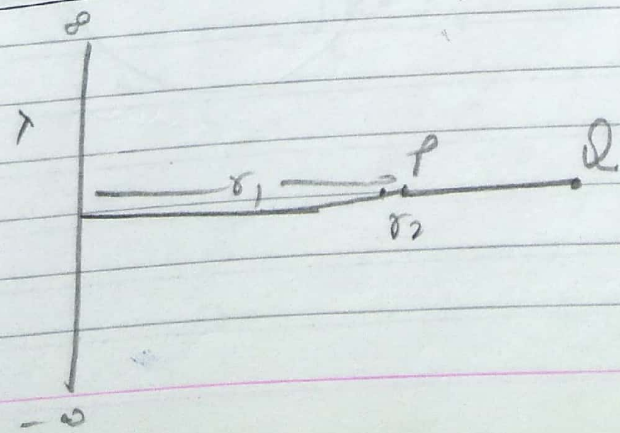
$$\vec{E} = -2y\hat{i} - 2x\hat{j}$$

$$E = -\frac{dv}{dr} = -\text{(slope of } v\text{-}r \text{ graph).}$$

* Electric potential due to charged objects

$$\Delta v = -\int \vec{E} \cdot d\vec{r}$$

i) Due to a long rod:

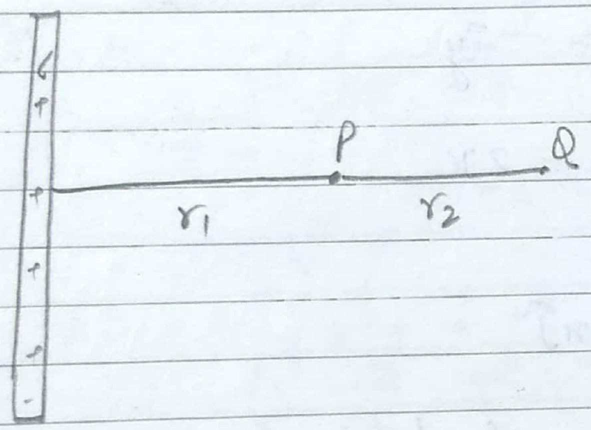


$$E = \frac{2k\lambda}{r}$$

$$\Delta V = -\int E\,dr = -\int_{r_1}^{r_2} \frac{2k\lambda}{r}\,dr$$

$$= -2k\lambda \ln\left(\frac{r_2}{r_1}\right)$$

(ii) <u>Large sheet</u>:-

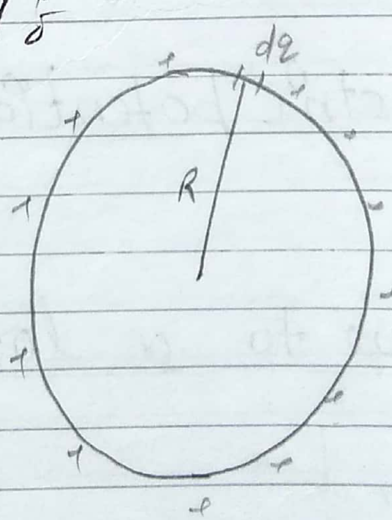


$$E = \frac{\sigma}{2\varepsilon_0}$$

$$\boxed{\Delta V = -\frac{\sigma}{2\varepsilon_0}(r_2 - r_1)}$$

(iii) <u>Potential due to a Ring</u>:

Complete Ring:-

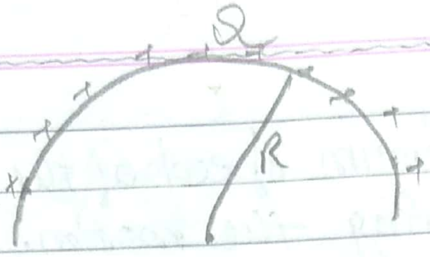


$$dV = \frac{k\,dq}{R}$$

$$V = \int_0^Q \frac{k}{R}\,dq$$

$$\boxed{V = \frac{kQ}{R}}$$

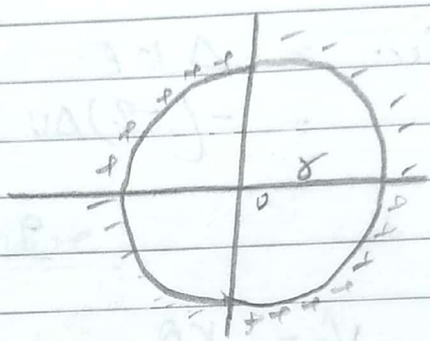
half Ring:



$$\boxed{V = \frac{kQ}{R}}$$

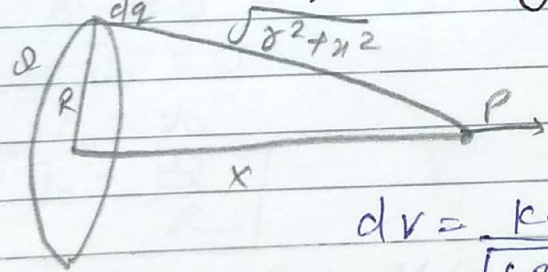
[and 1/4th ring $V = \frac{kQ}{R}$]

Que:



$V = \frac{kq}{r}$ Ans.

* At axis of Ring:



$\left(V_P = \frac{kQ}{\sqrt{R^2+x^2}}\right)$

$$dV = \frac{k\,dq}{\sqrt{(R^2+x^2)}}$$

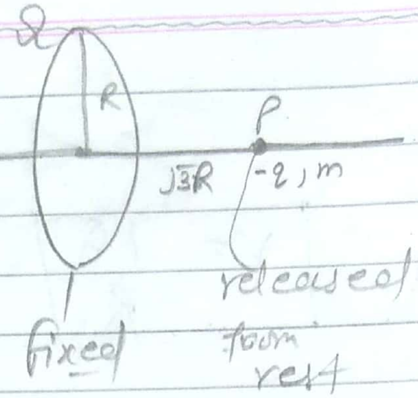
$$V = \frac{k}{\sqrt{R^2+x^2}}\int_0^Q dq$$

$$V_P = \frac{kQ}{\sqrt{R^2+x^2}}$$

Speed : ~~v~~ = ~~u~~

Race-9
{ O-1 ⇒ 35-40 Que

Que:
Find maximum speed of the particle during the motion.



Ans:

Work energy theorem

$W_{elec.} = \Delta KE$

$= -(-q)\Delta V = \frac{1}{2}m(v^2 - 0)$

$q(V_O - V_P) = \frac{1}{2}mv^2$

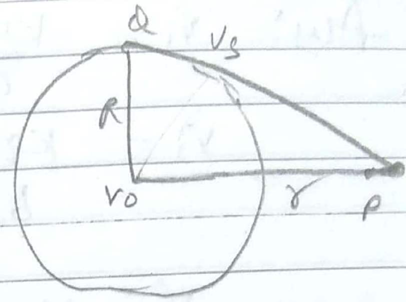
$V_O = \frac{KQ}{R}$

$V_P = \frac{KQ}{2R}$

Date: 23/05/17

* Potential due to a sphere:

i) Hollow sphere: $r > R$



$$V_{out} = \frac{KQ}{r}$$

$$V_{surface} = \frac{KQ}{R}$$

(ii) $r < R$ Inside the sphare:

$$E_{inside} = 0$$

$$\Delta V = -\vec{E} \cdot \Delta r$$

$$\Delta V = 0$$

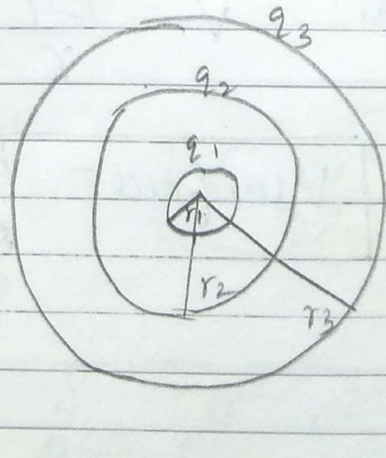
$$V_s - V_0 = 0$$

$$V_s = V_0$$

$$\boxed{V_0 = \frac{KQ}{R}}$$

- Inside of Hollow sphere potential at every point is same due to the sphere

Que! find Potential at each sphere:

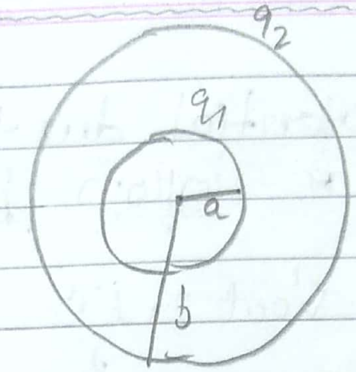


$$V_1 = \frac{Kq_1}{r_1} + \frac{Kq_2}{r_2} + \frac{Kq_3}{r_3}$$

$$V_2 = \frac{Kq_1}{r_2} + \frac{Kq_2}{r_2} + \frac{Kq_3}{r_2}$$

$$V_3 = \frac{Kq_1}{r_3} + \frac{Kq_2}{r_3} + \frac{Kq_3}{r_3}$$

Que: Find potential difference.



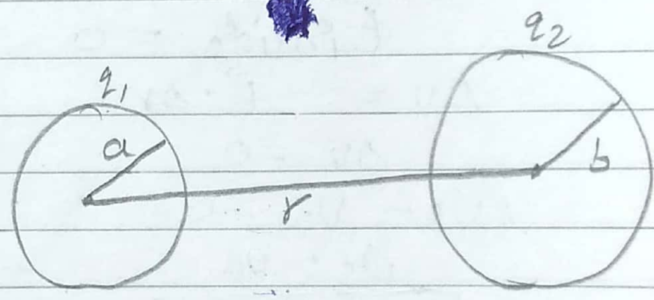
Ans: $V_1 \Rightarrow \dfrac{kq_1}{a} + \dfrac{kq_2}{b}$

$$V_2 = \frac{kq_2}{b} + \frac{kq_1}{a}$$

$$V_2 - V_1 = \frac{kq_1}{b} - \frac{kq_1}{a}$$

$$\Delta V = kq_1\left(\frac{1}{a} - \frac{1}{b}\right)$$

Que:

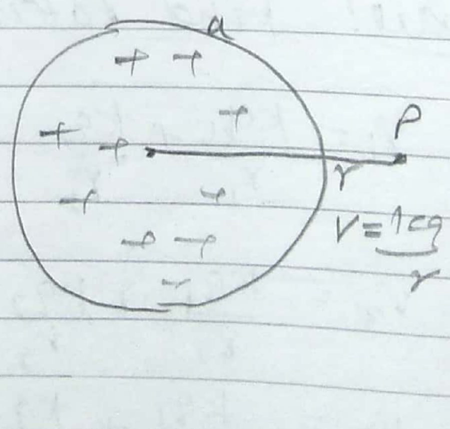


Ans: $V_1 \Rightarrow \dfrac{kq_1}{a} + \dfrac{kq_2}{r}$

$$V_2 = \frac{kq_2}{b} + \frac{kq_1}{r}$$

(ii) Solid Sphere (Non-Conducting):

$r > R$ Out side:



Ans: $V = \dfrac{kq}{r}$

$$\boxed{V_{surface} = \frac{kq}{R}}$$

→ Inside the sphere : $r < R$

$$\Delta V = -\int E\,dr$$

$$E_{inside} = \frac{\rho r}{3\varepsilon_0}$$

$$\Delta V = -\int_r^R \frac{\rho r}{3\varepsilon_0}\,dr$$

$$V_S - V_A = -\frac{\rho}{6\varepsilon_0}\left[r^2\right]_r^R$$

$$V_S - V_A = \frac{\rho}{6\varepsilon_0}(R^2 - r^2)$$

$$E_{inside} = \frac{\rho r}{3\varepsilon_0}$$

$$V_{surface} = \frac{Kq}{R} = \frac{1}{4\pi\varepsilon_0 R}\,\rho \times \tfrac{4}{3}\pi R^3$$

$$= \frac{\rho R^2}{3\varepsilon_0}$$

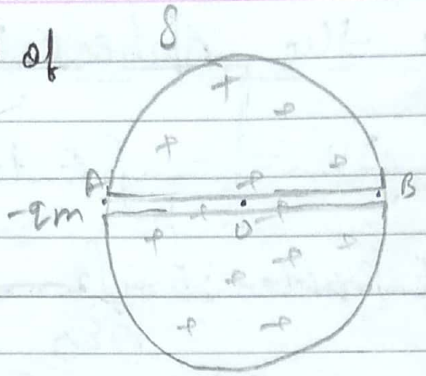
$$V_S + \frac{\rho}{6\varepsilon_0}(R^2 - r^2) = V_A$$

$$\boxed{V_0 = \frac{\rho R^2}{2\varepsilon_0}}$$

$$V_A = \frac{\rho R^2}{3\varepsilon_0} + \frac{3R^2}{6\varepsilon_0} - \frac{\rho r^2}{6\varepsilon_0}$$

$$V_A = \frac{3\rho R^2}{6\varepsilon_0} - \frac{\rho r^2}{6\varepsilon_0} = \boxed{V_A = \frac{\rho}{6\varepsilon_0}(3R^2 - r^2)}$$

Que: find Maximum Speed of Charge During the Motion.



Ans:

$$W_{elect.} = \frac{1}{2}mv^2 - 0$$

$$-(-q)(V_0 - V_A) = \frac{1}{2}mv^2$$

$$q\left(\frac{\delta R^2}{2\varepsilon_0} - \frac{\delta R^2}{3\varepsilon_0}\right) = \frac{1}{2}mv^2$$

$$\frac{\delta R^2 q}{6\varepsilon_0} = \frac{1}{2}mv^2$$

For time Period.

$$\left\{ \begin{array}{l} V_{max} = A\omega \\ T = \frac{2\pi}{\omega} \end{array} \right\}$$

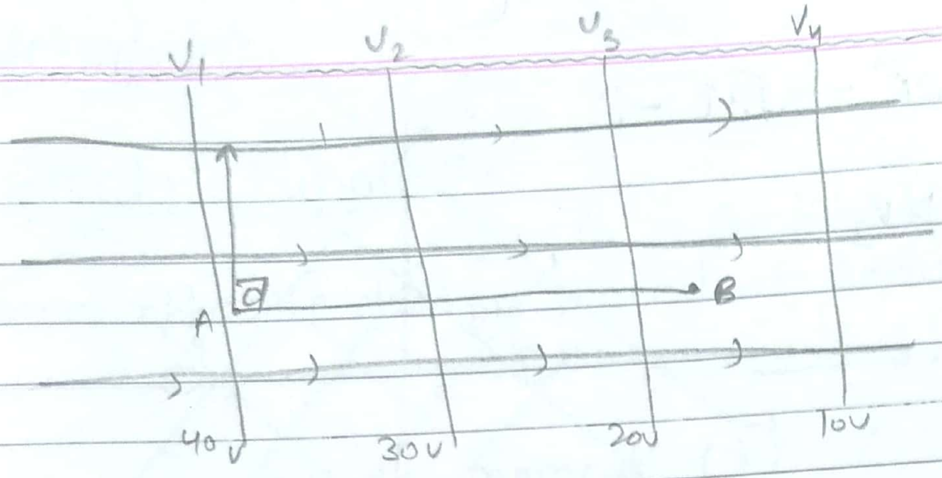
Equipotential Surface:

It is a Surface at which every point have same Potential

At equipotential Surface potential difference b/w any Two points is zero.

Work done to move a charge from one position to another on equipotential Surface always zero.

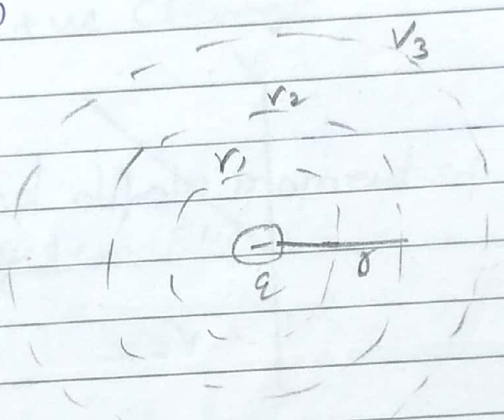
Equipotential Surface are always Perpendicular to the field lines



$$\Delta V = -E \cdot \Delta r \cos\theta$$

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

$$V_1 < V_2 < V_3$$



* Two equipotential Surface Never intersect

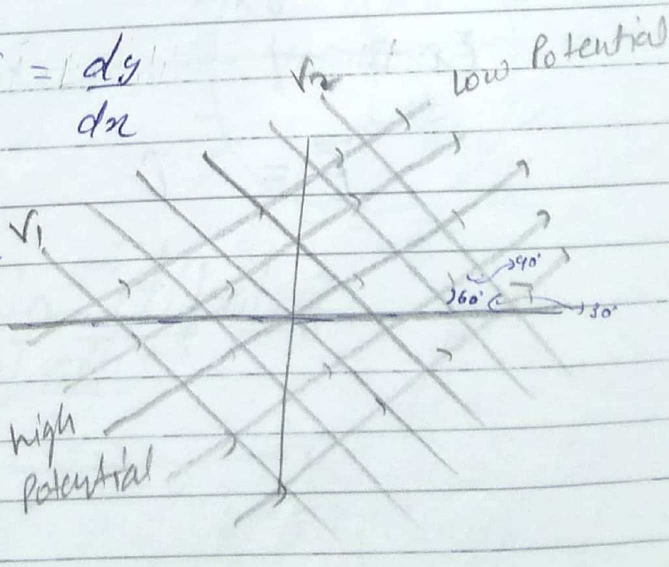
Que: $\vec{E} = \hat{i} + \sqrt{3}\hat{j}$ Draw field lines at equipotential Surface.

Ans: $\tan\theta = \frac{E_y}{E_x} = \sqrt{3} = \frac{dy}{dx}$

$$\int dy = \sqrt{3} \int dx$$

$$y = \sqrt{3}x + C$$

Ans

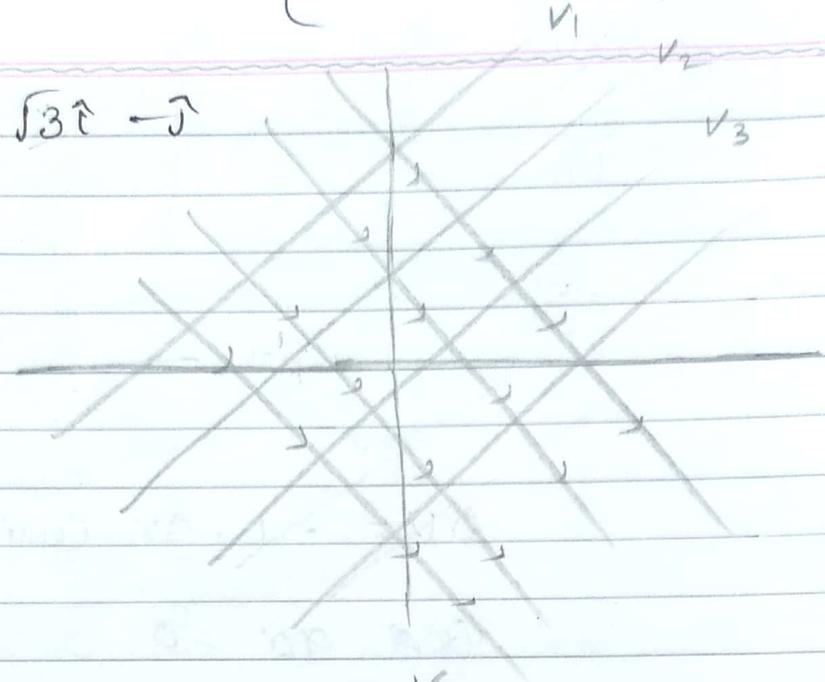


H.W ÷ Race-10
Ex- S-1 ⇒ 11, 12, 14, 15
O-1 ⇒ 41 to 53

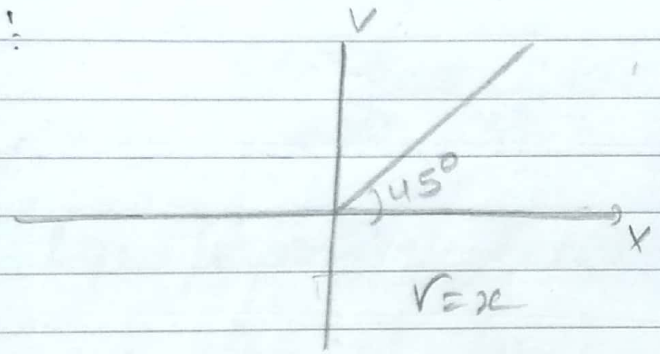
Que ÷ E.f $\vec{E} = \sqrt{3}\hat{i} - \hat{j}$

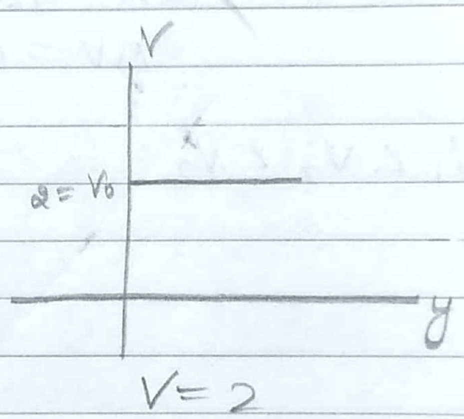
Ans:

$V_1 > V_2 > V_3$



Que:





Draw field lines.

$V = x + 2$

$E_x = -\frac{\partial V}{\partial x}$ $\qquad$ $E_y = -\frac{\partial V}{\partial y}$

$E_x = -1$ $\qquad$ $E_y = 0$

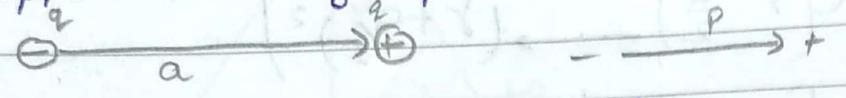
$\vec{E} = -\hat{i}$

$\frac{4r}{3\pi}$ – at Disc

Date: 29/05/17

* Electric dipole :

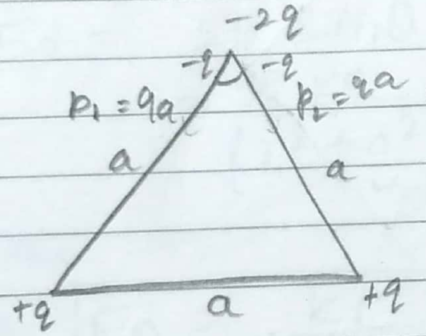
It is a combination of two equal and opposite charges placed at some distance.



Dipole moment ($\vec{p}$)

$$p = |q| a$$

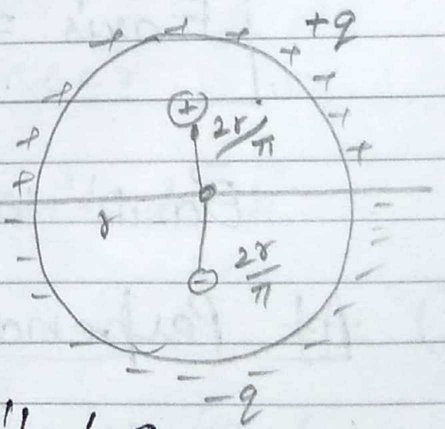
from –ve to +ve charge

Que: 

⇒ find dipole moment of the system.

Sol:
$$\sqrt{p_1^2 + p_2^2 + 2p_1p_2\cos\theta} = qa\sqrt{3}$$

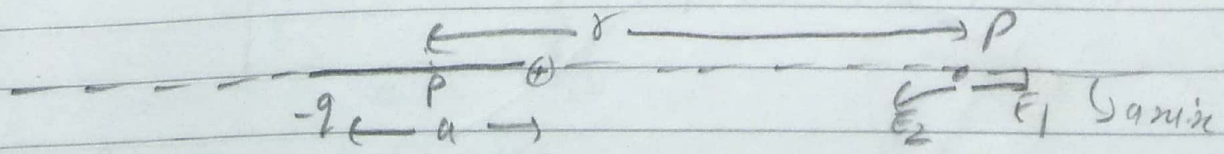
Que: find dipole moment of the ring



Ans: $\vec{p} = \frac{q4r}{\pi}\hat{j}$

* Electric field due to dipole:

i) At the axis of dipole:



Samir

$$E_P = E_1 - E_2$$

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

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

$$E_P = kq\left[\frac{\left(r+\frac{a}{2}\right)^2 - \left(r-\frac{a}{2}\right)^2}{\left(r^2-\frac{a^2}{4}\right)}\right]$$

$$E_P = \frac{kq \cdot 2ra}{\left(r^2 - \frac{a^2}{4}\right)^2}$$

$$\boxed{E_{axis} = \frac{2kpr}{\left(r^2-\frac{a^2}{4}\right)^2}}$$

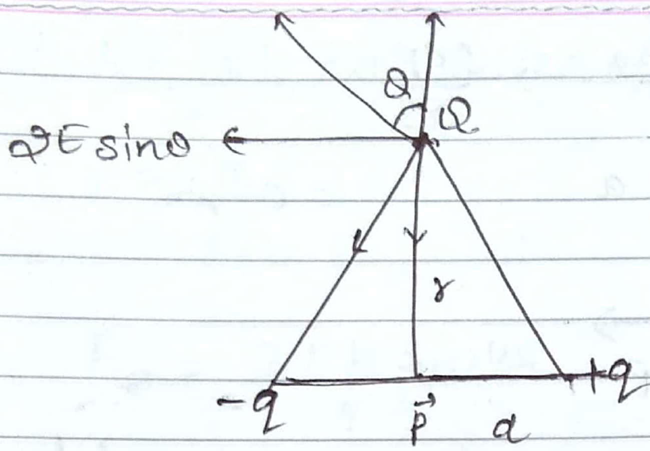
Small dipole

$a << r$

$$\boxed{E_{axis} = \frac{2kp}{r^3}}$$

$\vec{E}_{axis}$ is Parallel $\vec{p}$

(ii) At Perpendicular bisector :- (equitorial line) :-



$$= \frac{kq}{\left(r^2 + \frac{a^2}{4}\right)}$$

$$E_Q = 2E\sin\theta$$

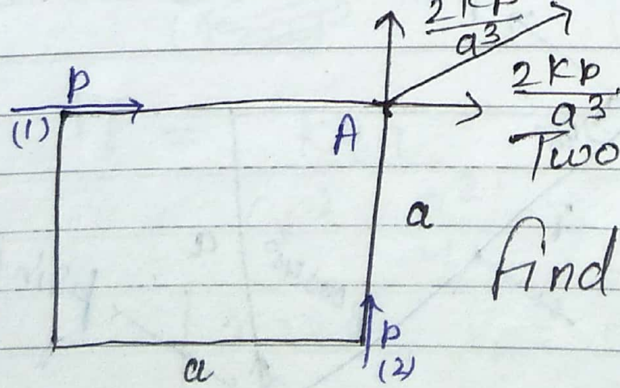
$$= \frac{2kq}{\left(r^2 + \frac{a^2}{4}\right)} \quad \frac{a}{2\left(r^2 + \frac{a^2}{4}\right)^{1/2}}$$

$$\boxed{E_Q = \frac{kp}{\left(r^2 + \frac{a^2}{4}\right)^{3/2}}}$$

Small dipole. a << r

$$\boxed{E_Q = \frac{kp}{r^3}}$$ opposite to $\vec{p}$

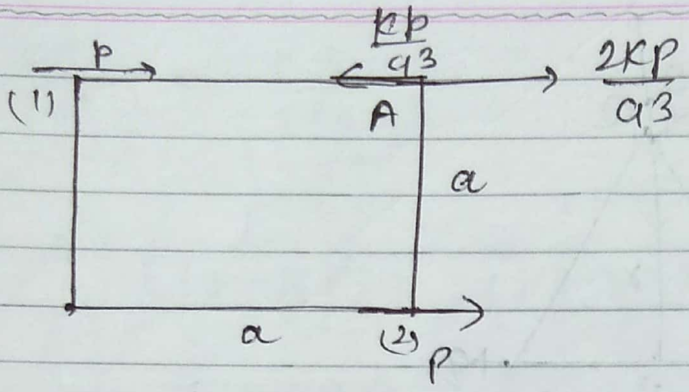
Que:



Two small dipole
Find Net EF at A.

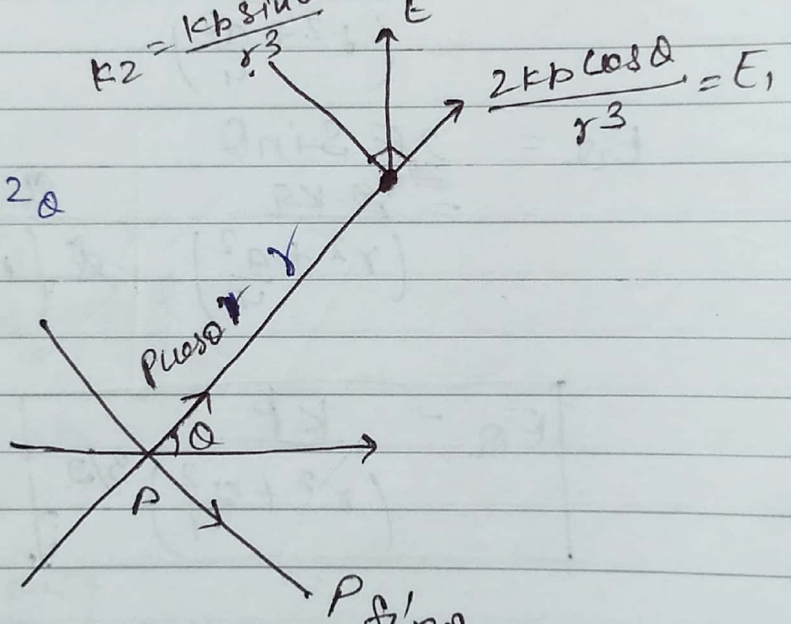
Ans: $2\sqrt{2}\,\frac{kp}{a^3}$

Que!



$= 0$ Ans

* E.f due to dipole at any General point:



$E = \sqrt{E_1^2 + E_2^2}$

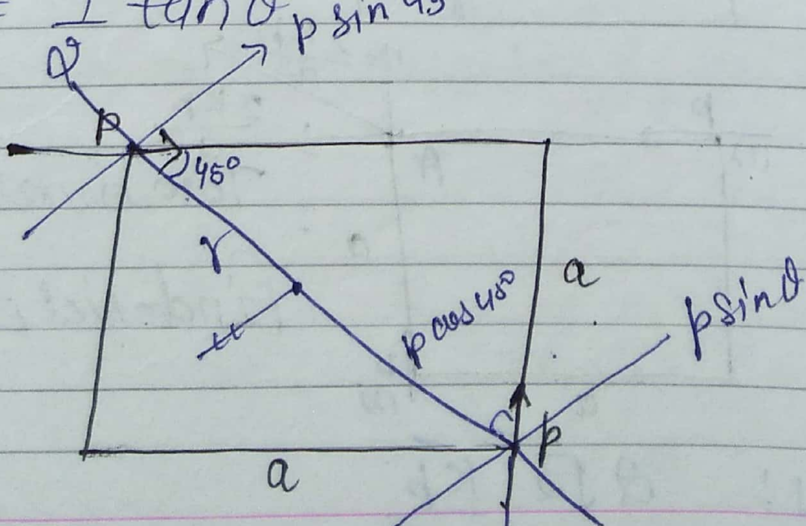
$= \frac{kp}{r^3}\sqrt{\sin^2 + 4\cos^2\theta}$

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

$\tan\alpha = \frac{E_2}{E_1}$

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

Que:



Que:

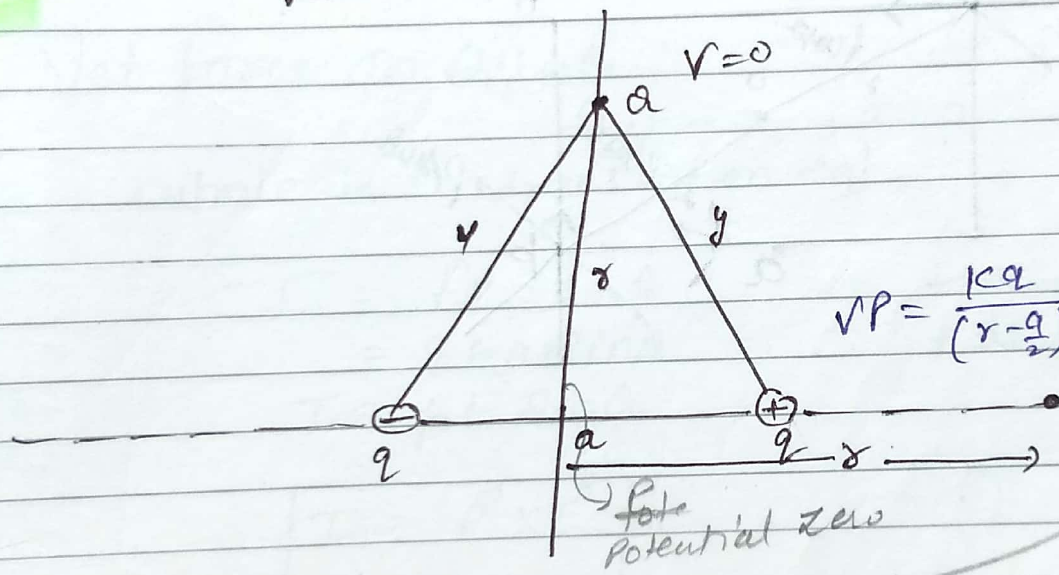
find E.f at the centre of square:-

Ans:

$$r = \frac{a}{\sqrt{2}}$$

$$E_0 = \frac{2kp \sin 45}{r^3}$$

* Electric potential due to dipole :-



$$VP = \frac{kq}{(r-\frac{a}{2})_P} - \frac{kq}{(r+\frac{a}{2})}$$

$\cancel{\frac{2kp}{(r+a)^2}}$

$$V_P = kq\left(\frac{r+\frac{a}{2} - r+\frac{a}{2}}{(r^2 - \frac{a^2}{4})}\right)$$

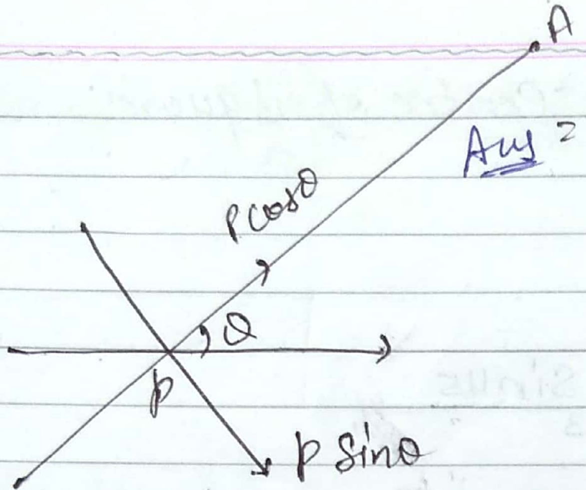
$\cancel{\frac{2kp}{(r-a)^2}}$

$$VP = \frac{kqa}{(r^2 - \frac{a^2}{4})} = \boxed{V_P = \frac{kp}{(r^2 - \frac{a^2}{4})}}$$

$$\boxed{r >> a \quad V_P = \frac{kp}{r^2}}$$

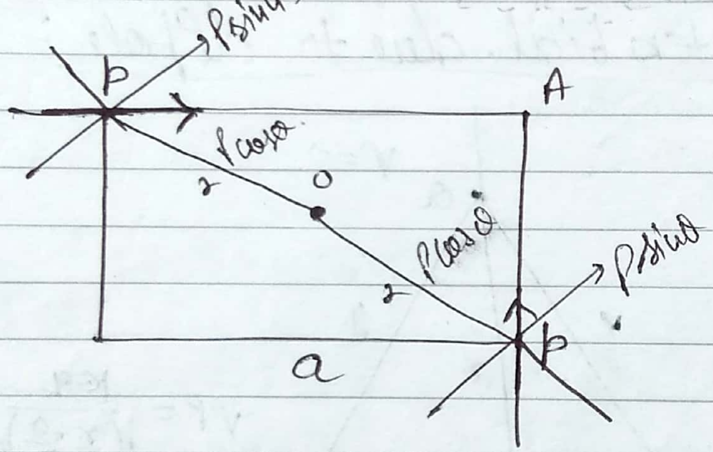
H.W.: S-1: E.P. Energy upto 15 Que. 16, 17,
O-1: 54, 55, 56, 57

Que:



Ans $= \frac{KP\cos\theta}{r^2}$

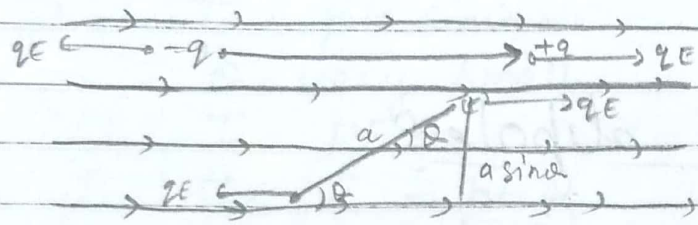
Que:



Date: 25/05/17

* Electric dipole in External ~~dipole~~ field:

(i) Uniform Electric field:



Net force on Dipole:-

$f_{net} = 0$, $a = 0$

Dipole is in translation eqb.

$\tau = f \cdot a \sin\theta$ — -ve - inside

$= qEa \sin\theta$ — +ve - outside

$\tau = pE \sin\theta$

$$\boxed{\tau = \vec{P} \times \vec{E}}$$

$\vec{\tau}$ is Perpendicular to $\vec{P}$ as well as $\perp^{al}$ $\vec{E}$

{ anticlockwise rotate = $\tau = +ve$
clockwise rotate = $\tau = -ve$ }

* Potential Energy of Dipole: It is the work done to rotate ~~the~~ a dipole in External Electric field

$PE = U = W$

$= \tau d\theta$

$$= pE\int \sin\theta d\theta$$

$$U = -pE\cos\theta$$

$$\boxed{U = -\vec{p}\cdot\vec{E}}$$

* Equilibrium of dipole:

$F_{net} = 0$

$\tau = pE\sin\theta$

$U = -pE\cos\theta$

for eqb.

$F_{net} = 0$

$\tau = 0$

$\theta = 0^\circ, 180^\circ$

If U - max. {unstable}

U - min {Stable}

if $\theta = 0$, $U = -pE$ - stable

$\theta = 180^\circ$, $U = pE$ - unstable.

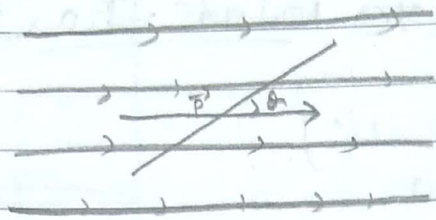
Que: Find workdone to Bring the Dipole from unstable eqb. to stable eqb.

Ans:

$$W = U_f - U_i = -2pE$$

Note: If a dipole is slightly displaced from stable eqb. then It perform S.H.M about eqb position

$p = q\frac{4r}{\pi}$



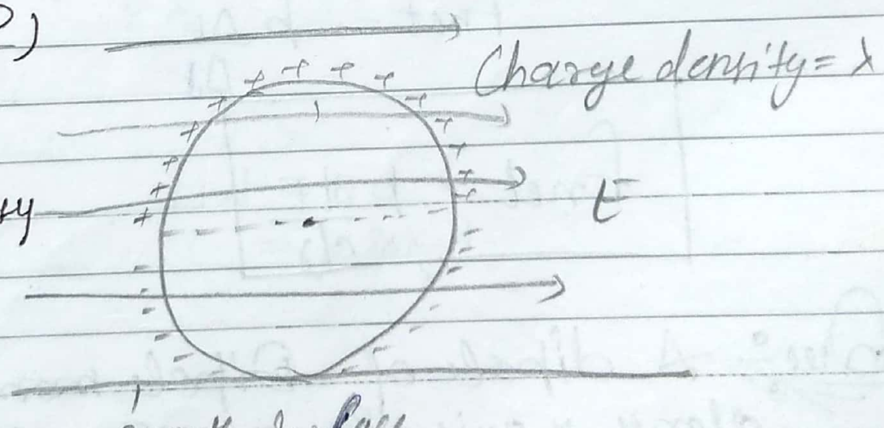
$$\tau = pE\sin\theta$$
θ = very small
$$\tau = pE\theta$$
$$I_{cm}\alpha = pE\theta$$

$$\alpha = \left(\frac{pE}{I}\right)\theta = \alpha = \omega^2\theta$$

$$\omega = \sqrt{\frac{pE}{I}} \quad ; \quad T = \frac{2\pi}{\omega} = \boxed{T = 2\pi\sqrt{\frac{I_{cm}}{pE}}}$$

Que: Ring (m, R)

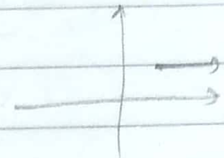
find Net force
τ Potential Energy
and angular acc.
of the ring.
Just after E.f in
switch on.



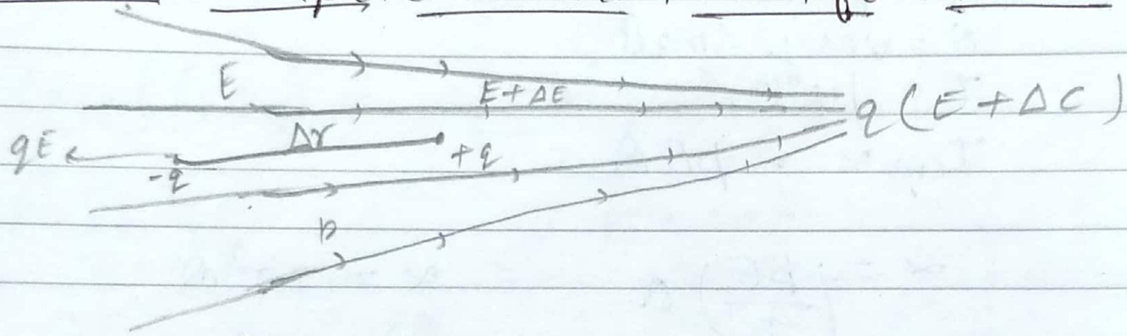
Ans:
$$U = 0$$
$$\tau = pE \qquad q = \lambda\pi R$$
$$p = \frac{4R}{\pi} = \frac{\lambda\pi R\, 4R}{\pi} = 4\lambda R^2$$
$$= 4\lambda R^2 E = I\alpha$$
$$\alpha = \frac{4\lambda E}{m}$$

(ii) Find work done by E.f to Rotate the ring by 90°:

$$W_{elect} = -(U_f - U_i)$$
$$= pE$$



* Electric dipole in non-uniform E.f:



$$f_{net} = q\Delta E$$
$$= (q\Delta r)\frac{\Delta E}{\Delta r}$$
$$f_{net} = p\frac{\Delta E}{\Delta r}$$

$$\boxed{f_{net} = p\frac{dE}{dr}}$$

Que: A dipole of Dipole moment p placed along x axis in a region where E.f is $\vec{E} = E_0 x\hat{i}$ N/C find force on the dipole.

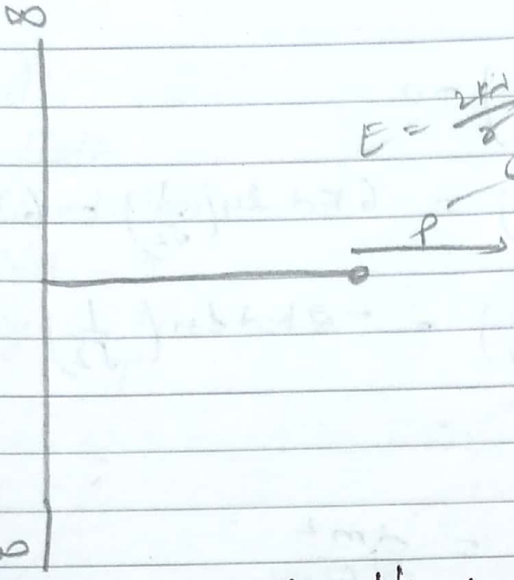
Ans: $f_{net} = p\frac{dE}{dx}$

$$= pE_0$$

+ Repulsion

H.W ⇒ S-1: upto 18 Que
S-2: 6, 9,
O-1 ⇒ upto 61.
O-2 ⇒ 10, 11, 12, 14, 15, 16
17.

Que:



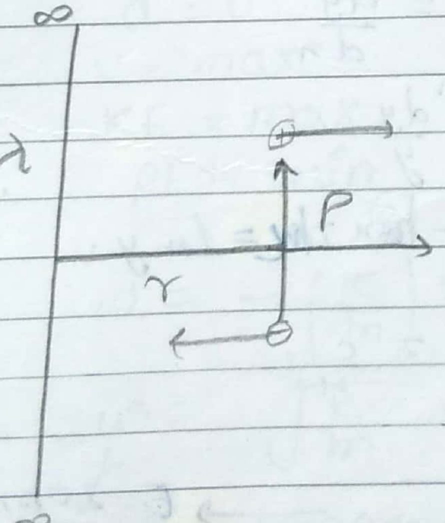
→ find force on the dipole due to wire.

Ans:- $E = \frac{2k\lambda}{r}$

$f = p\frac{dE}{dr}$

$f = -p\frac{2k\lambda}{r^2}$

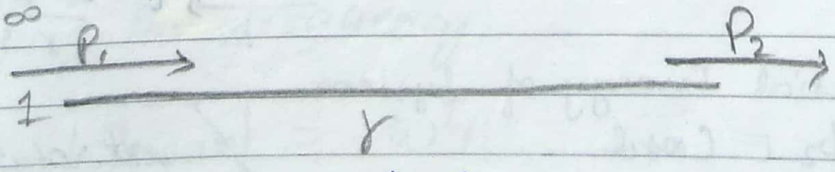
Que:



$F_{net} = 0$

$\tau = p\frac{2k\lambda}{r}$

Que:



$f = p_2\frac{dE}{dr}$

$= p_2\left(\frac{-6kp}{r^4}\right)$

E.F due to dipole 1

$E = \frac{2kp_1}{r^3}$

$f = -\frac{6kp_1p_2}{r^4}$

Date: 26/05/17 O-2

(12) $V_x = -2K2d \ln\left(\frac{r_2}{r_1}\right) = 0$

$V_y = -2K3d \ln\left(\frac{r_2}{r_1}\right) = -6Kd \ln\left(\frac{1}{\sqrt{2}}\right) = 6Kd \ln 2$

$V_2 = -2Kd \ln\left(\frac{r_2}{r_1}\right) = -2Kd \ln\left(\frac{1}{\sqrt{2}}\right)$

$= Kdm^2$

$= 4Kdm^2$

$= \frac{4 \times dm^2}{4\pi\varepsilon_0} = \frac{dm^2}{\pi\varepsilon_0}$

(14) $V = x^2 - y^2$

$E_x = -\frac{\partial V}{\partial x} = -2x \qquad \vec{E} = -2x\hat{i} + 2y\hat{j}$

$\tan\theta = \frac{-y}{x} = \frac{dy}{dx}$

$E_y = 2y \qquad -\int \frac{dx}{x} = \int \frac{dy}{y}$

$\ln x + \ln y = \ln c \qquad -\ln x + \ln c = \ln y.$

$xy = c$

$y = \frac{c}{x}$

Que: r, $\overleftarrow{P_1}$, $\overrightarrow{p_2}$, $E = \frac{2Kp_1}{r^3}$

Find potential Energy of system

$V = -p_2 E \cos\theta$

$= -\frac{2Kp_1p_2}{r^3}$

$\boxed{\text{wt. rotate } \perp \text{ dipole} \quad W = \frac{2Kp_1p_2}{r^3}}$