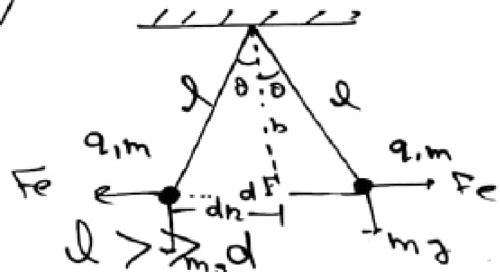
Question based on Coulomb's Law

JEE(M) NEET (2017)

$x << l$

$v = \frac{dx}{dt}$



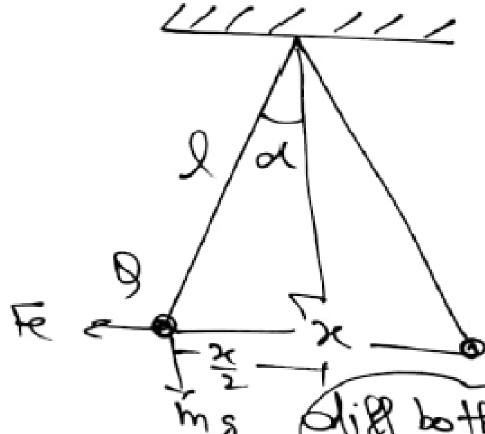
$l >> d$

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

$\frac{d}{2b} = \frac{kq^2}{d^2 mg}$

Charges are leaking with constant rate.

③ Find relation b/w v & x.



$\tan\alpha = \frac{F_e}{mg}$

$\frac{x}{2 \times l} = \frac{kQ^2}{x^2 mg}$

$x^3 \propto Q^2$

$Q^2 \propto x^3$

$Q \propto x^{3/2}$

diff both side w.r.t t

$\frac{d}{dt}(Q) \propto \frac{d}{dt}(x^{3/2})$

$\frac{dQ}{dt} \propto \frac{3}{2} x^{3/2-1} \cdot \frac{dx}{dt}$

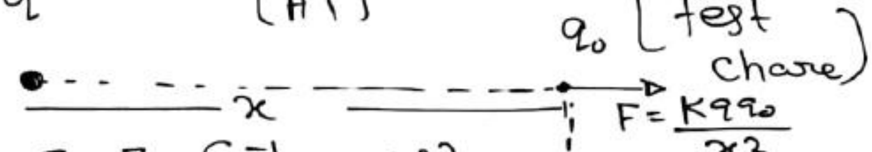
$\frac{dQ}{dt} \propto \frac{3}{2} x^{1/2} v$

$v \propto x^{-1/2}$

↳ **Electric field** :- → It is a vector quantity

↳ SI Unit → N/C

$$[E] = \frac{[MLT^{-2}]}{[AT]}$$



$$F = \frac{Kqq_0}{x^2}$$

$$[E] = [A^{-1}LMT^{-3}]$$

$$[E] = [MLT^{-3}A^{-1}]$$

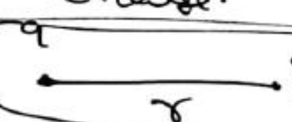
$$\vec{E} = \frac{\vec{F}}{q_0} = \frac{Kq\cancel{q_0}}{x^2\cancel{q_0}}$$

$$\vec{E} = \frac{Kq}{x^2}$$

q_0
- ↳ Small positive charge
- ↳ No displacement of q due to test charge (q_0)

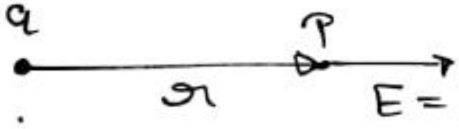
⊕ **Electric field** ($\vec{E}$) :- Electric field due to charge definite at any point is equal to ratio of Force on that Point on test charge divide by test Charge.

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



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

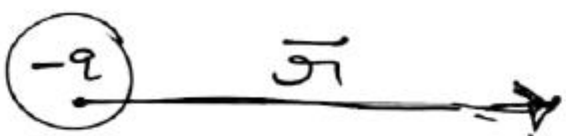
Electric field:-



$$E = \frac{Kq}{r^2} \qquad \left(\hat{r} = \frac{\vec{r}}{r}\right)$$

$$\vec{E} = \frac{Kq}{r^2}\,\hat{r}$$

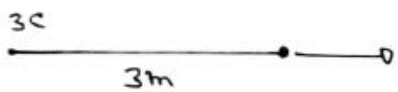
$$\vec{E} = \frac{Kq}{r^3}(\vec{r})$$



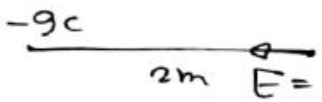
$$E = \frac{Kq}{r^2}$$

$$\vec{E} = \frac{Kq}{r^2}(-\hat{r})$$

$$\vec{E} = \frac{Kq}{r^3}(-\vec{r})$$

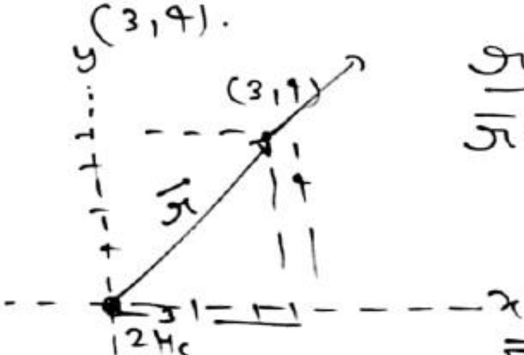
Q1) 

$E = \frac{Kq}{r^2} = \frac{9\times10^9 \times 3}{3^2} = 3\times10^9$ N/c

Q2) 

$E = \frac{K(9)}{2^2} = \frac{9\times10^9 \times 9}{4}$ N/c

\# A charge ($q = 2\mu c$) placed at (0,0). find electric field at (3,4).



$r = 5m$

$\vec{r} = 3\hat{i} + 4\hat{j}$

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

$E = \frac{9\times10^9 \times 2\times10^{-6}}{5^2}$

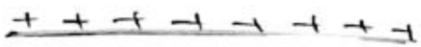
$E = \frac{18\times10^3}{25}$

$\vec{E} = \frac{Kq}{r^3}(\vec{r})$

$\vec{E} = \frac{9\times10^9 \times 2\times10^{-6}(3\hat{i}+4\hat{j})}{5^3} = \frac{18\times10^3(3\hat{i}+4\hat{j})}{125}$ N/C

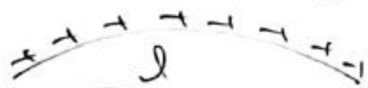
$\lambda = \frac{20}{10} = 2\ C/m$

q, l



λ = linear charge density

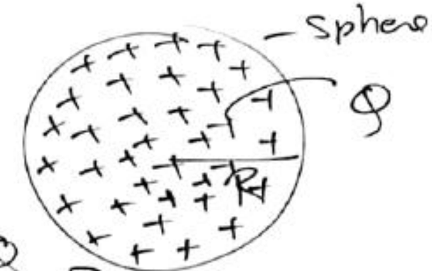
$\lambda = \frac{q}{l}$



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

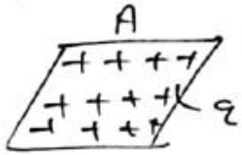
Volume charge density

ρ

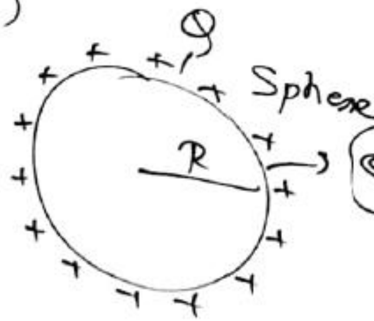


$\rho = \frac{Q}{V}\ [C/m^3]$

Surface charge density (σ)



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



$\sigma = \frac{Q}{4\pi R^2}$

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

Ex)

$\sigma = \frac{20}{100} = \frac{1}{5} = 0.2\ C/m^2$

Electric field

(i) Electric field due to point charge [& vector form]

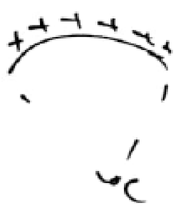
(ii) Electric field due to charge circular arc & due to circular ring at axis point)

(iii) Electric field due to charge [finite, infinite, semi infinite rod]

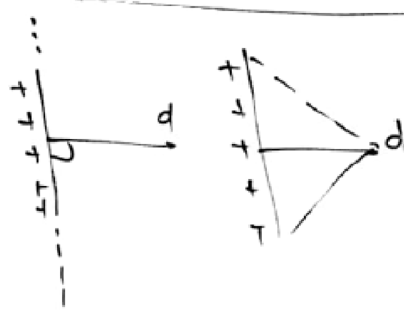
(iv) Electric field due to dipole

(v) Electric field due to [Hollow, solid,] charged sphere.

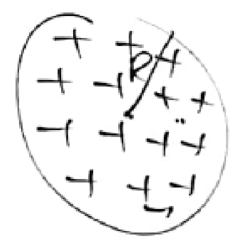
(ii)



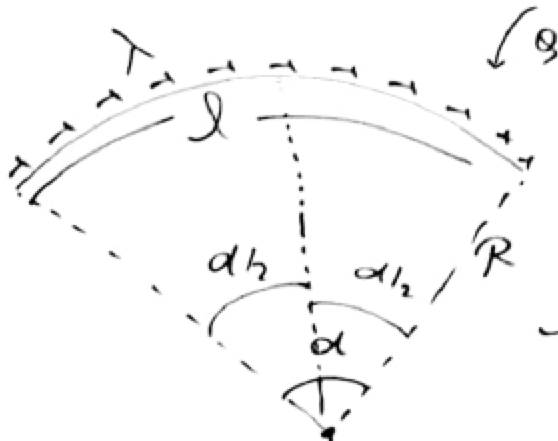
(iii)



(V)

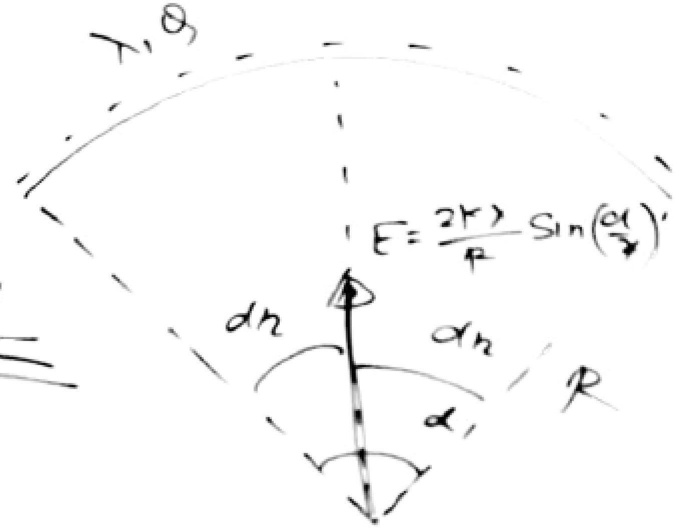


Electric field due to charge circular arc.

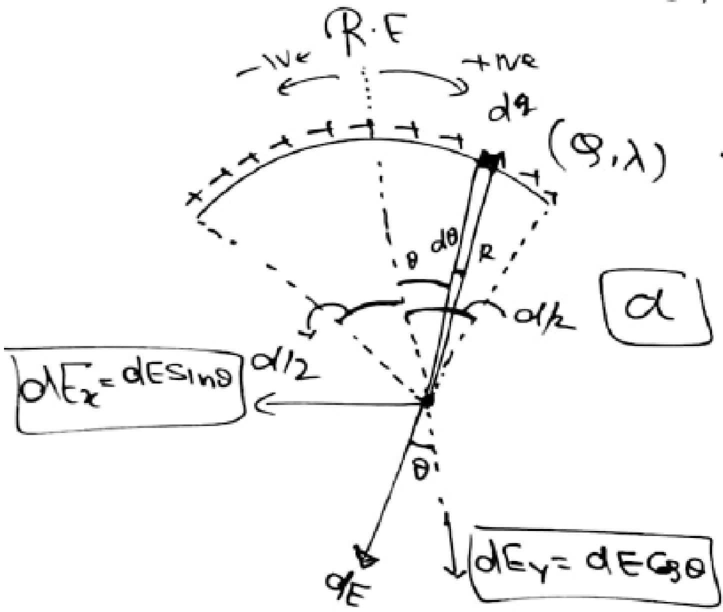


$$l = R\alpha$$

$$\frac{2K\lambda}{R}\left(\sin\frac{\alpha}{2}\right)$$



Electric field due to charge circular arc at centre.



α

$$\left[\lambda = \frac{q}{l}\right] \qquad q = \lambda l$$

$$dq = \lambda dx$$

$$dx = R\,d\theta$$

→ Electric field due to dq element at Centre.

$$dE = \frac{K\,dq}{R^2} \Rightarrow dE = \frac{K\lambda dx}{R^2} = \frac{K\lambda R\,d\theta}{R^2}$$

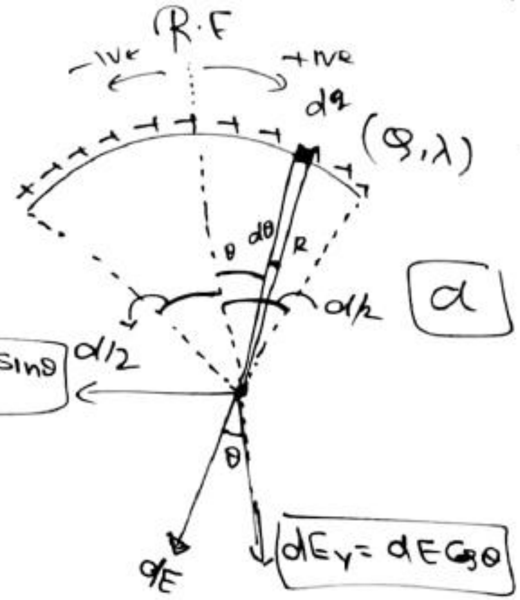
$$\boxed{dE = \frac{K\lambda}{R}\,d\theta}$$

$$dE_x = \left(\frac{K\lambda}{R}\,d\theta\right)\sin\theta \Rightarrow \int dE_x = \frac{K\lambda}{R}\int_{-\alpha/2}^{+\alpha/2} \sin\theta\,d\theta$$

$$E_x = \frac{K\lambda}{R}\left[-\cos\theta\right]_{-\alpha/2}^{\alpha/2}$$

$$E_x = \frac{K\lambda}{R}\left[-\cos\frac{\alpha}{2} - \left(-\cos\left(\frac{\alpha}{2}\right)\right)\right] = 0$$

Electric field due to a charge circular arc at centre.



$\left[\lambda = \frac{q}{l}\right]$

$q = \lambda l$

$dq = \lambda dx$

$dx = R d\theta$

→ Electric field due to dq element at centre.

$dE = \frac{K dq}{R^2} \Rightarrow dE = \frac{K \lambda dx}{R^2} = \frac{K \lambda R d\theta}{R^2}$

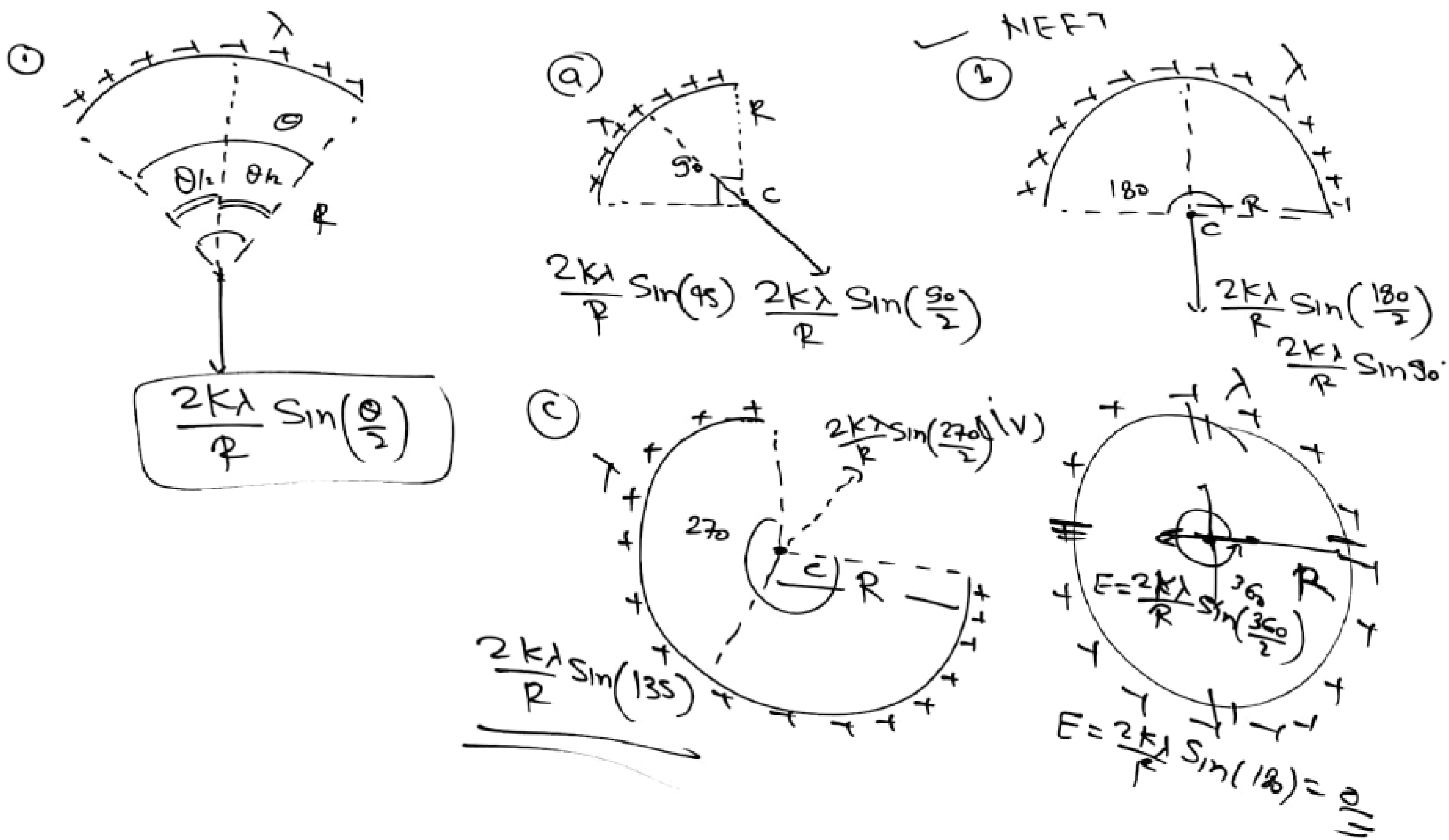
$$\boxed{dE = \frac{K\lambda}{R} d\theta}$$

$$\int dE_y = \frac{K\lambda}{R} \int_{-\alpha/2}^{\alpha/2} \cos\theta \, d\theta$$

$$= \frac{K\lambda}{R} \left[\sin\theta\right]_{-\alpha/2}^{\alpha/2}$$

$$= \frac{K\lambda}{R}\left(\sin\frac{\alpha}{2} - \left(\sin\left(-\frac{\alpha}{2}\right)\right)\right)$$

$$\boxed{= \frac{2K\lambda}{2} \sin\frac{\alpha}{2}}$$


NEET
①
λ
θ
θ/2 θ/2
R
$\frac{2K\lambda}{R}\sin\left(\frac{\theta}{2}\right)$
ⓐ
R
90
C
$\frac{2K\lambda}{R}\sin(45)$ $\frac{2K\lambda}{R}\sin\left(\frac{90}{2}\right)$
ⓑ
λ
180
R
C
$\frac{2K\lambda}{R}\sin\left(\frac{180}{2}\right)$
$\frac{2K\lambda}{R}\sin 90$
ⓒ
λ
270
C
R
$\frac{2K\lambda}{R}\sin\left(\frac{270}{2}\right)$
$\frac{2K\lambda}{R}\sin(135)$
λ
R
360
$E=\frac{2K\lambda}{R}\sin\left(\frac{360}{2}\right)$
$E=\frac{2K\lambda}{R}\sin(180)=0$