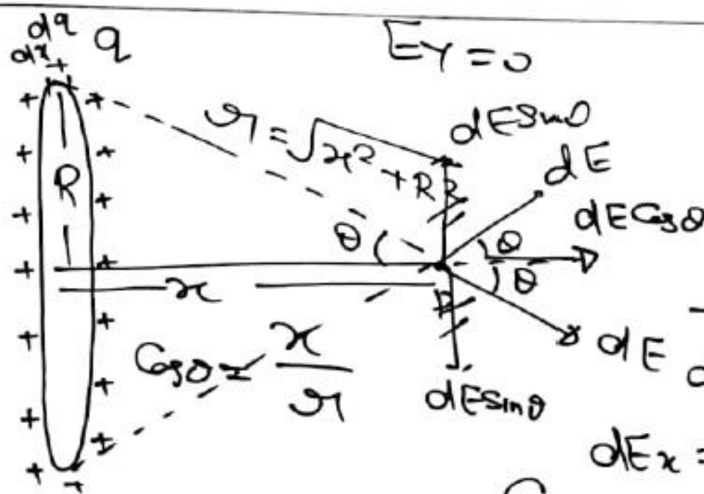
2) Electric field due to circular ring at its axis.



Electric field due to small element dq at point P

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

→ Component of electric field in dirn x.

$$dE_x = dE\cos\theta = \frac{K\,dq}{r^2}\cos\theta$$

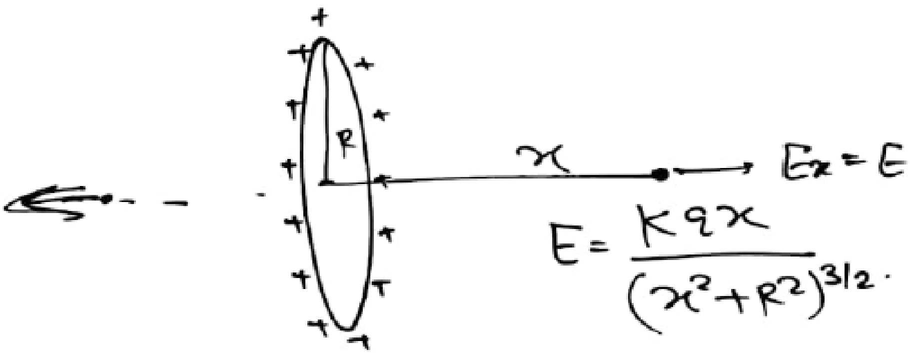
$$dE_x = \frac{K\cos\theta}{r^2}\int dq = \frac{Kq\cos\theta}{r^2}$$

$$E_x = \frac{Kq}{r^2}\times\frac{x}{r} = \frac{Kqx}{r^3}$$

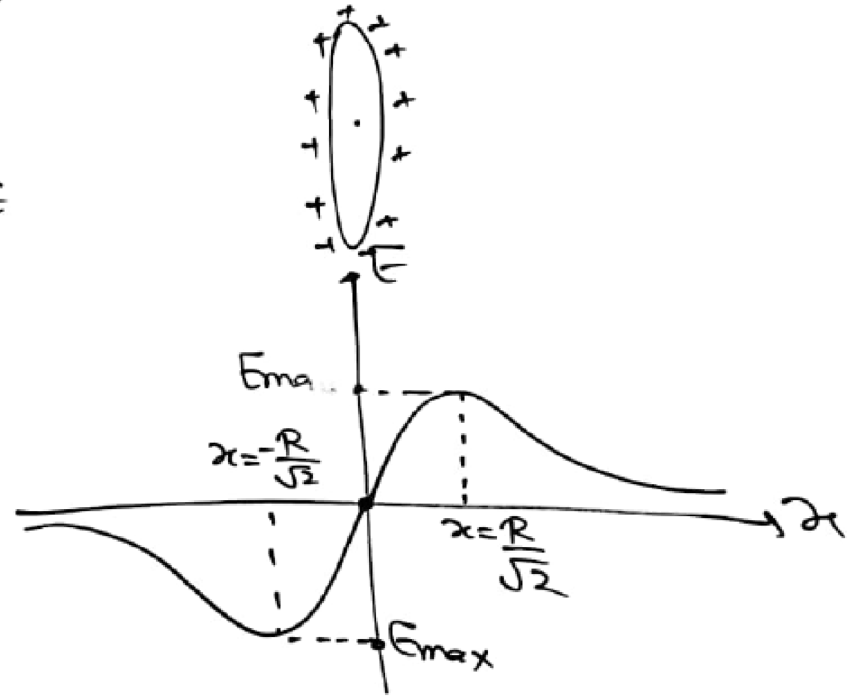
$$E_x = \frac{Kqx}{\left(\sqrt{x^2+R^2}\right)^3} = \frac{Kqx}{(x^2+R^2)^{3/2}}.$$

$$\boxed{E_x = \frac{Kqx}{(x^2+R^2)^{3/2}}}$$

Electric field due to circular ring at its axial position



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



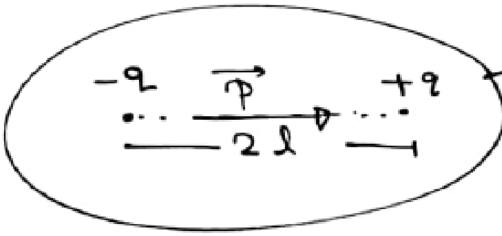
$\underline{x=0}$ its centre.

$$\underline{\underline{E=0}}$$

x = Far point $\boxed{x >> R}$

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

Dipole ($\vec{p}$) :- It is system of two equal charges of opposite polarity placed at small distance.



Electric dipole

Na^+ Cl^-

$\downarrow$

Electric dipole

$\Rightarrow$ dipole moment $\vec{p} = q(2l)$

$\downarrow$

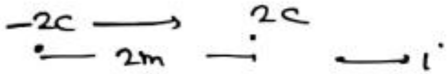
dir^n $\rightarrow$ $-q$ to $+q$

SI Unit - C-m

(Q2) Na^+ & Cl^- placed at 1 Å distance. find its dipole moment.

$$P = q\times(d)$$
$$= 1.6\times10^{-19}\times10^{-10}$$
$$\boxed{P = 1.6\times10^{-29}\ \text{C-m}}$$

Q1)



$P = ?$

$P = (2)(2m)$

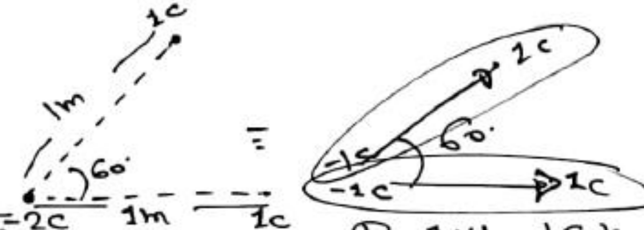
$= 4\ C\text{-}m$

$\underline{P = 4\ C\text{-}m}$

Q3)

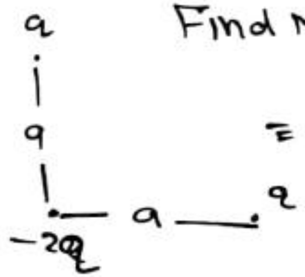
$\Rightarrow P_{net} = \sqrt{P^2 + P^2 + 2PP\cos 60}$

$P_{net} = P\sqrt{3}$ $= 1\sqrt{3}\ C\text{-}m$



$P = 1 \times 1 = 1\ C\text{-}m$

Q2) Find Net dipole moment

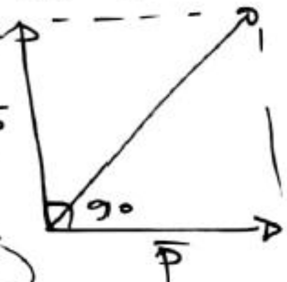


=

$P = q\,a$

$\boxed{P = (q \cdot a)}$

$= \bar{P}$

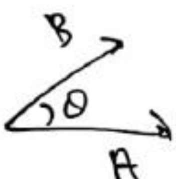


$P_{net} = \sqrt{P^2 + P^2 + 2\underbrace{PP\cos 90}_{0}}$

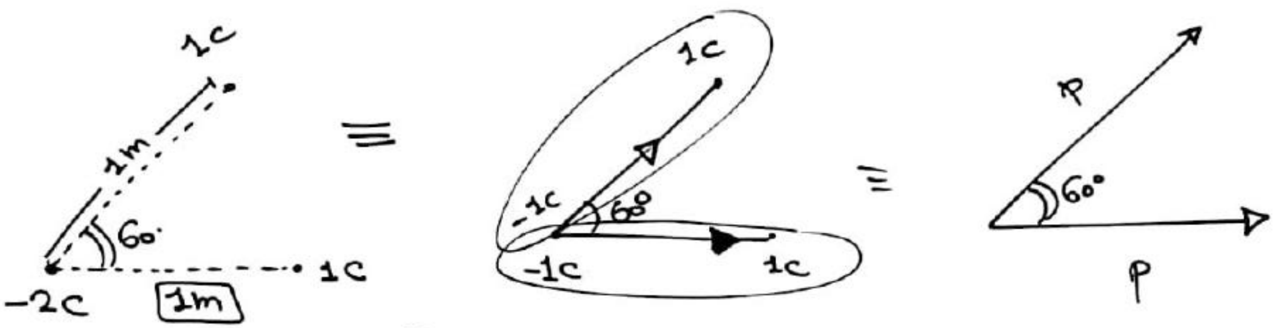
$= \sqrt{2P^2}$

$= P\sqrt{2}$

$\boxed{P_{net} = qa\sqrt{2}}$



$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$



$P = 1 \times 1m$

$\underline{P = 1c\text{-}m}$

$$R = \sqrt{P^2 + P^2 + 2 \times P \times P \cos 60^\circ}$$

$$= \sqrt{2P^2 + 2P^2 \cos 60^\circ}$$

$$= \sqrt{2P^2 + \cancel{2}P^2 \times \frac{1}{\cancel{2}}}$$

$$= \sqrt{2P^2 + P^2} = \sqrt{P^2 \times 3}$$

$$P_{net} = P\sqrt{3}$$

$$\underline{= 1\sqrt{3}\ \text{cm}}$$

⇨ Electric field due to dipole at axial point :-

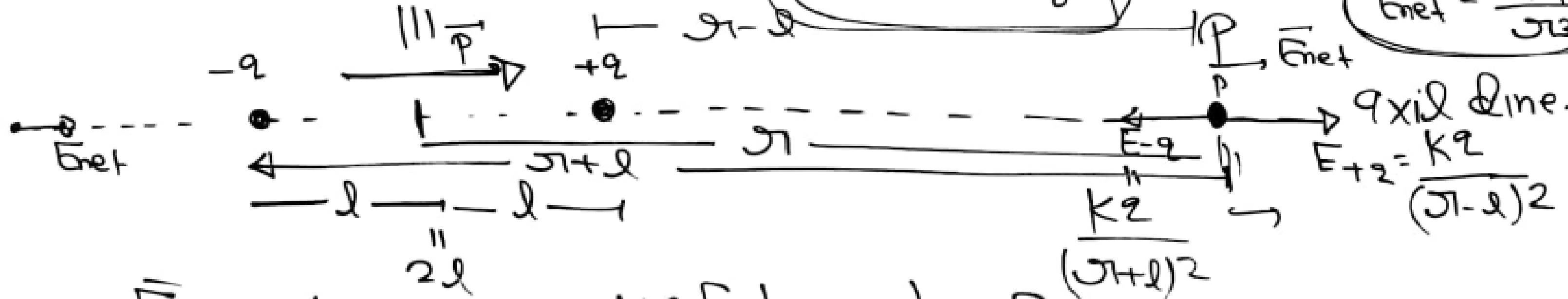
$\vec{p} = q[2l]$ $\longrightarrow$

$$\boxed{\vec{E}_{net} = \frac{2K\vec{p}\,r}{(r^2-l^2)^2}}$$

[If $r >> l$]

$$E_{net} = \frac{2Kpr}{r^4} = \frac{2Kp}{r^3}$$

$$\vec{E}_{net} = \frac{2K\vec{p}}{r^3}$$



$= 2l$

$$\vec{E}_{net} = \frac{Kq}{(r-l)^2} - \frac{Kq}{(r+l)^2} = Kq\left[\frac{1}{(r-l)^2} - \frac{1}{(r+l)^2}\right]$$

$$\vec{E}_{net} = Kq\left[\frac{(r+l)^2 - (r-l)^2}{(r-l)^2(r+l)^2}\right] \Rightarrow \vec{E}_{net} = Kq\left[\frac{\cancel{r^2}+\cancel{l^2}+2rl-\cancel{r^2}-\cancel{l^2}+2rl}{(r^2-l^2)^2}\right]$$

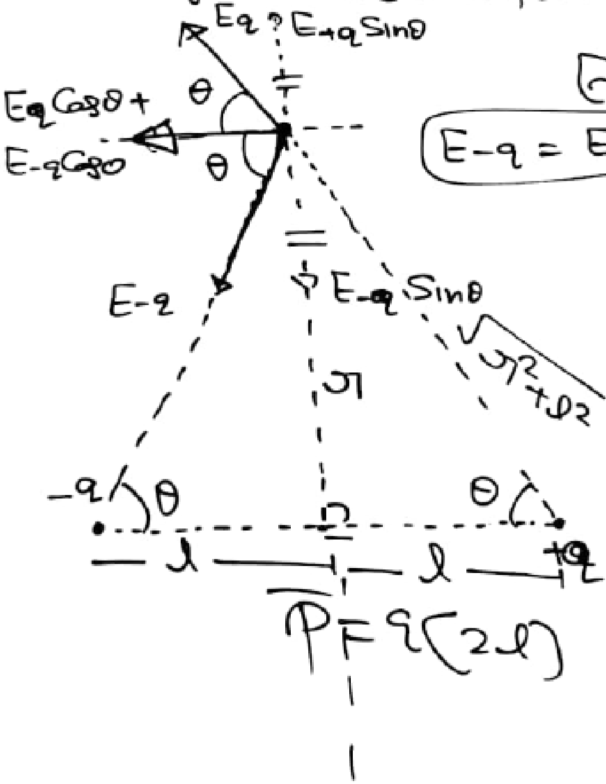
$$(r-l)(r-l)\,(r+l)(r+l)$$

$$(r^2-l^2)(r^2-l^2) = (r^2-l^2)^2$$

$$E_{net} = \frac{Kq[4rl]}{(r^2-l^2)^2} = \frac{K2r[q \times 2l]}{(r^2-l^2)^2}$$

$$E_{net} = \frac{2Kpr}{(r^2-l^2)^2}$$

[Electric field due to dipole at Equitorial / Perpendicular position]



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

$$\boxed{E_{-q} = E_{+q}}$$

$$E_{net} = 2\left[\frac{Kq}{(r^2+l^2)}\right] \times \left(\frac{l}{\sqrt{l^2+r^2}}\right)$$

$$E_{net} = \frac{2Kql}{(r^2+l^2)(r^2+l^2)^{1/2}}$$

$$E_{net} = \frac{K(2ql)}{(r^2+l^2)^{3/2}}$$

$$\vec{E}_{net} = \frac{-K\vec{P}}{(r^2+l^2)^{3/2}}$$

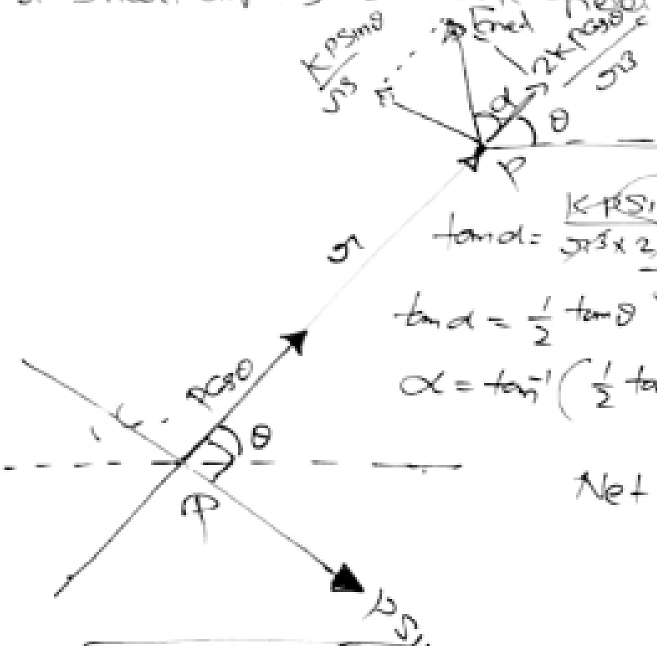
For Short dipole ($r >> l$)

l – small

l^2 very small $\simeq 0$

$$\boxed{\vec{E}_{net} = \frac{-K\vec{P}}{r^3}}$$

(For short dipole) Electric field at General point



$\tan\alpha = \dfrac{\frac{Kp\sin\theta}{r^3}}{\frac{2Kp\cos\theta}{r^3}}$

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

$\alpha = \tan^{-1}\left(\frac{1}{2}\tan\theta\right)$

→ Net dir of electric field from Horizontal

↳ $\theta + \alpha$

$= \boxed{\theta + \tan^{-1}\left(\frac{1}{2}\tan\theta\right)}$

For $p\cos\theta$ – Point P is axial point

For $p\sin\theta$ → Point P is equitorial point.

Net Electric field $E = \sqrt{E_\perp^2 + E_\parallel^2}$

$$\boxed{E = \frac{Kp}{r^3}\sqrt{1+3\cos^2\theta}}$$

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

$$E_{net} = \sqrt{\left(\frac{2Kp\cos\theta}{r^3}\right)^2 + \left(\frac{Kp\sin\theta}{r^3}\right)^2}$$

$$= \sqrt{\frac{4K^2p^2\cos^2\theta}{r^6} + \frac{K^2p^2\sin^2\theta}{r^6}} = \frac{Kp}{r^3}\sqrt{4\cos^2\theta + \sin^2\theta} = \frac{Kp}{r^3}\sqrt{3\cos^2\theta + \underbrace{\cos^2\theta + \sin^2\theta}_{1}}$$