ABLES® KOTA

⇒ Electoric field

#) q —— r —— $E = \dfrac{Kq}{r^2}$

(a) λ, d → $E = \dfrac{2K\lambda}{d}$

(b) λ, d → $E_{\perp} = \dfrac{K\lambda}{d}$, $E_{\parallel} = \dfrac{K\lambda}{d}$

(ii) λ c/m, α, R, P

$E = \dfrac{2K\lambda}{R}\sin\dfrac{\alpha}{2}$

(iii) λ, d, θ_1, θ_2

$E_{\perp} = \dfrac{K\lambda}{d}\left[\sin\theta_1 + \sin\theta_2\right]$

$E_{\parallel} = \dfrac{K\lambda}{d}\left[\cos\theta_2 - \cos\theta_1\right]$

(iv) Q, R, x, P

E, x, $-\dfrac{R}{\sqrt{2}}$, $\dfrac{R}{\sqrt{2}}$

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

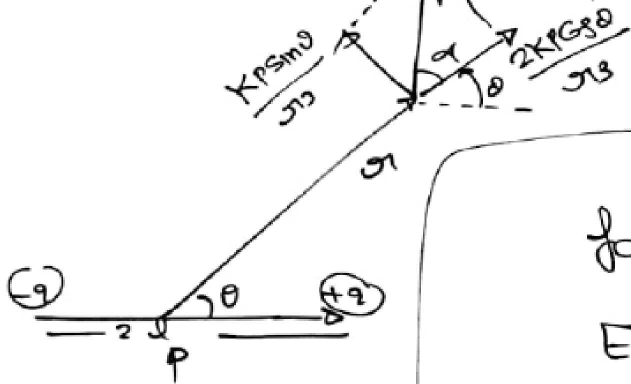
(v) p, r

$\vec{E} = \dfrac{2K\vec{p}}{r^3}$ [short dipole]

(vi) E, r, p

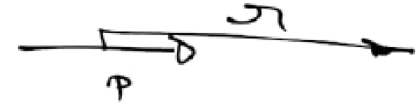
$\vec{E} = -\dfrac{K\vec{p}}{r^3}$

Electric field due to dipole at general point



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

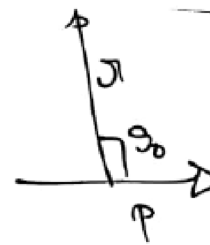
for axial point $[\theta = 0]$



$$E_{axial} = \frac{Kp}{r^3}\sqrt{1+3\cos^2 0}$$

$$= \frac{Kp}{r^3}\sqrt{1+3} = \frac{Kp}{r^3}\sqrt{4} = \boxed{\frac{2Kp}{r^3}}$$

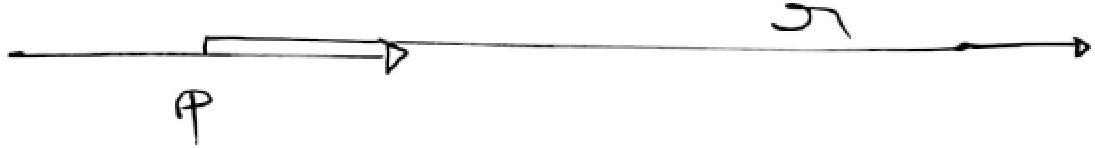
for equitorial point $[\theta = 90]$



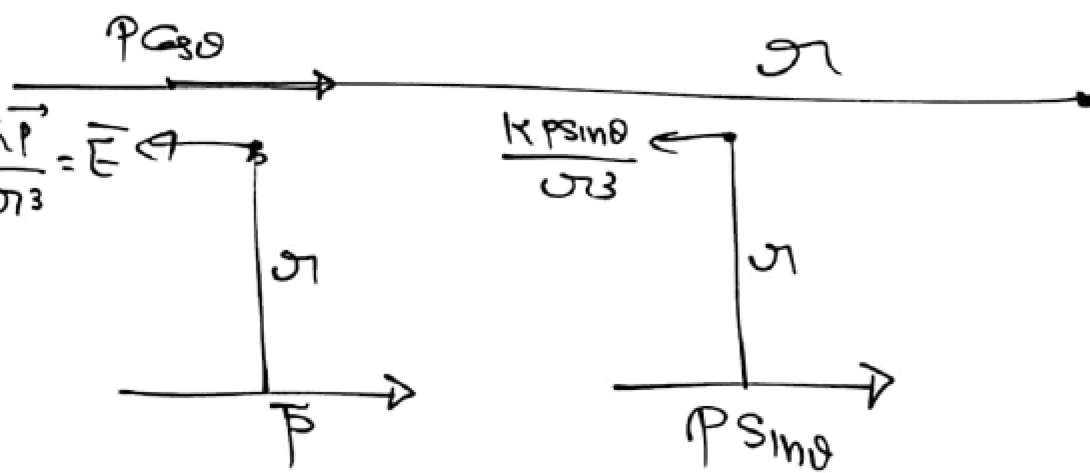
$$E_{equi} = \frac{Kp}{r^3}\sqrt{1+3\underbrace{\cos^2 90}_{0}}$$

$$\boxed{E_{eq.} = \frac{Kp}{r^3}}$$

Electric field due to dipole at general point



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

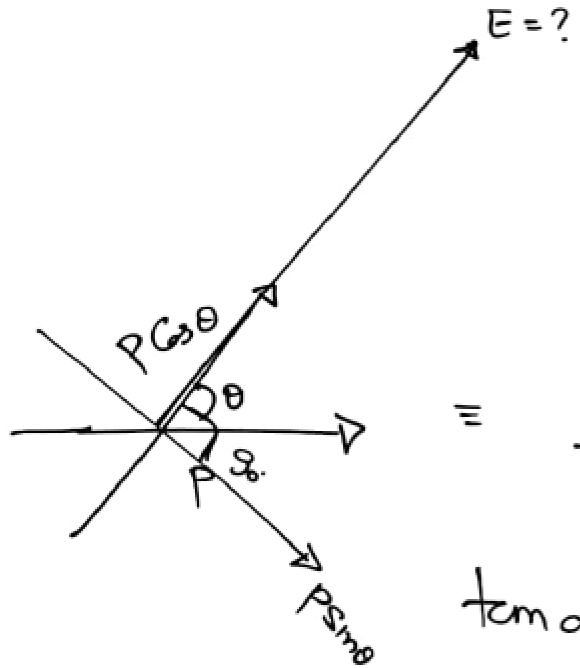


$$E = \frac{2Kp\cos\theta}{r^3}.$$

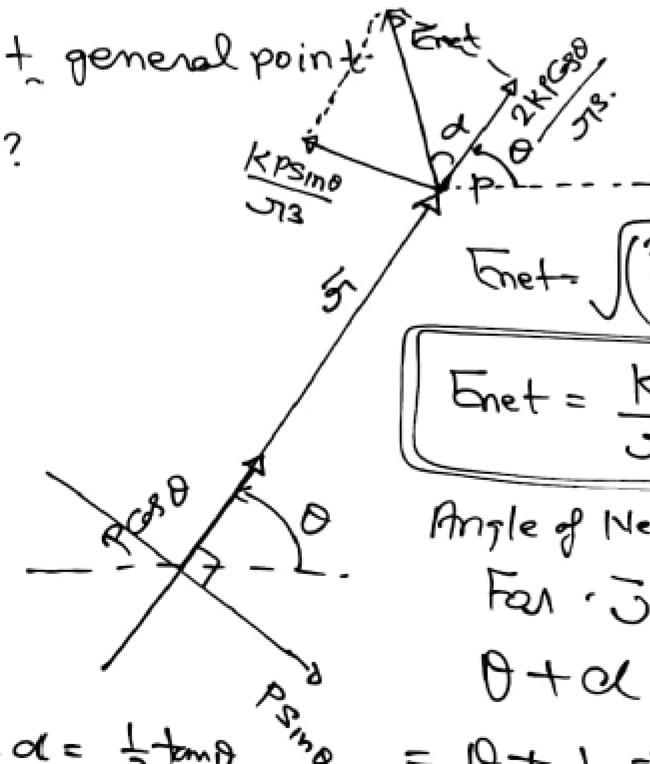
$$-\frac{K\vec{p}}{r^3} = \vec{E}$$

$$\frac{Kp\sin\theta}{r^3}$$

Electric field due to dipole at general point



≡



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

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

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

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

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

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

Angle of Net electric field

For $\vec{r}$ horizontal

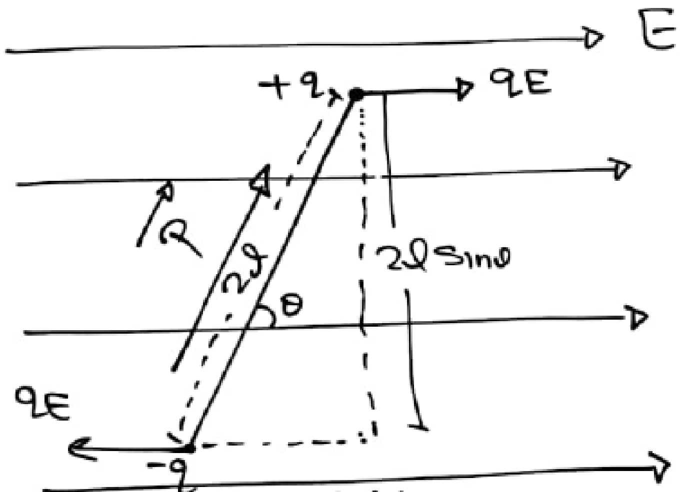
$$\theta + \alpha$$

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

(c) Electric dipole placed in Uniform electric field :-

(i) Net Force on dipole = $\underline{\underline{0}}$

** "In Uniform electric field, Net Force on dipole must be zero"



(ii) Torque = $r \times F$

$= \underline{\underline{rF\sin\theta}}$

$\boxed{\tau = r_{\perp} F}$

$\tau = (2l\sin\theta \times qE)$

$\tau = (2lq)E\sin\theta$

$\tau = pE\sin\theta$

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

$\tau = (2l \times qE)\sin\theta$

$\tau = (q \times 2l)E\sin\theta$

$\tau = pE\sin\theta$

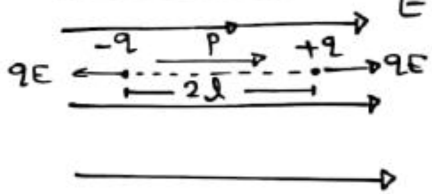
$\boxed{\vec{\tau} = \vec{p} \times \vec{E}}$

$\theta \rightarrow$ Angle b/w electric dipole moment & Electric field.

$\vec{\tau} = \vec{p} \times \vec{E}$ $pE\sin\theta = \tau$

Electric dipole placed in Uniform electric field :-

(a) $\boxed{\text{If } \theta = 0}$ angle b/w $\vec{P}$ & $\vec{E}$)



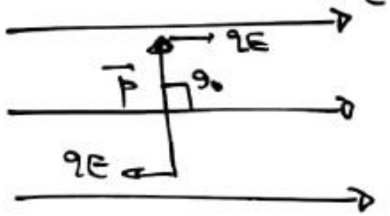
$\vec{F}_{net} = 0$

$\tau = PE\sin\theta$

$\tau = PE\sin 0$

$\boxed{\tau = 0}$

(b) If $\theta = 90$ [Angle b/w $\vec{P}$ & $\vec{E}$ is $90°$]



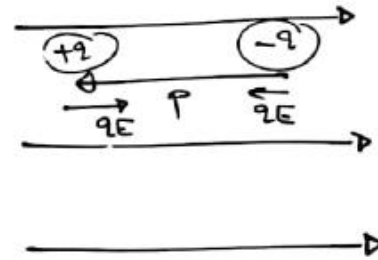
$\vec{F}_{net} = 0$

$\tau = PE\sin 90$

$\boxed{\tau = PE} \rightarrow$ max

$F = 0, \tau = 0$

(c) $\theta = 180°$ [Angle b/w $\vec{P}$ & $\vec{E}$ is $180°$]



$\vec{F}_{net} = 0$

$\tau = PE\sin 180$

$\boxed{\tau = 0}$

Equilibrium of a System

- $F = 0$
- $\tau = 0$

Equilibrium of dipole in Uniform Electric field:

- $\theta = 0$
- $\theta = 180$

→ Stable equilibrium

→ Unstable equilibrium

⇒ Q1 Find Net Force & Torque on dipole [whose dipole moment 2 C-m] is placed in uniform electric field ($\bar{E}$ = 20 N/C) at angle [(i) $\theta = 0$ (iv) $\theta = 120$
(ii) $\theta = 60°$ (v) $\theta = 180$
(iii) $\theta = 90$

$\boxed{F=0}$

(i) $\tau = PE\sin\theta$
$\theta = 0$
$\tau = 0$

(ii) $\tau = PE\sin 60$
$= \cancel{2} \times 20 \times \frac{\sqrt{3}}{\cancel{2}} = 20\sqrt{3}$ N-m

(iii) $\tau = PE\sin 90 = 2 \times 20 \times 1 = 40$ N-m

(iv) $PE\sin 120 = \tau$
$\tau = \cancel{2} \times 20 \times \frac{\sqrt{3}}{\cancel{2}}$
(iv) $= 20\sqrt{3}$ N-m

$\sin(90+30) = \cos 30 = \frac{\sqrt{3}}{2}$

(v) $\tau = 0$ $F = 0$

↳

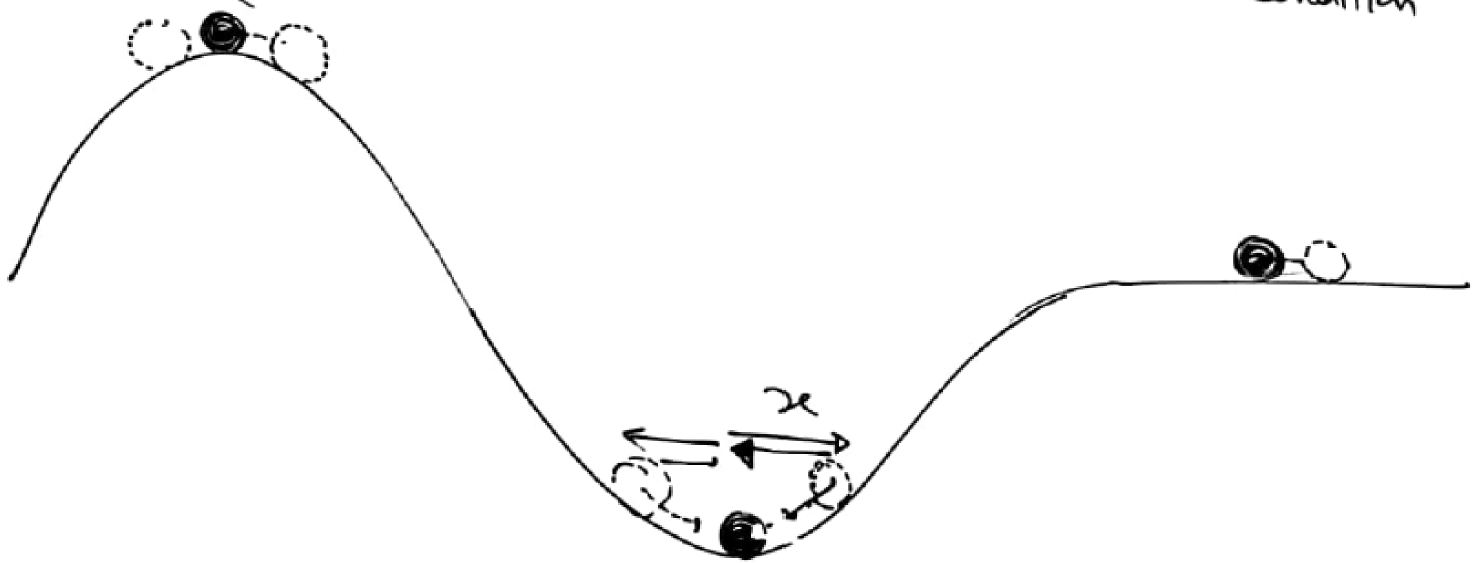
$\boxed{\text{Equilibrium } F=0,\ \tau=0}$

$\boxed{\vec{F} \propto -\vec{x}}$

Stable equilibrium Condition

$F=0$ — Translation equilibrium

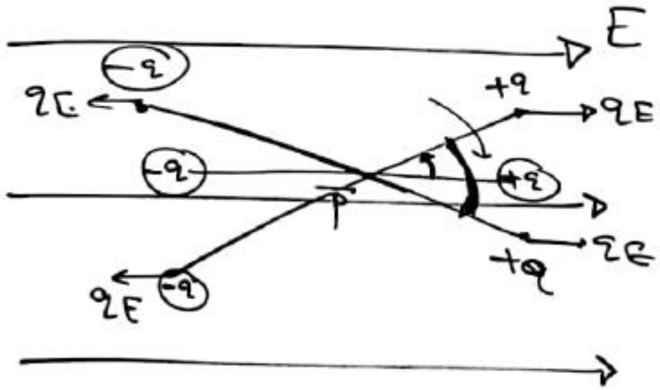
$\tau=0$ — Rotational equilibrium

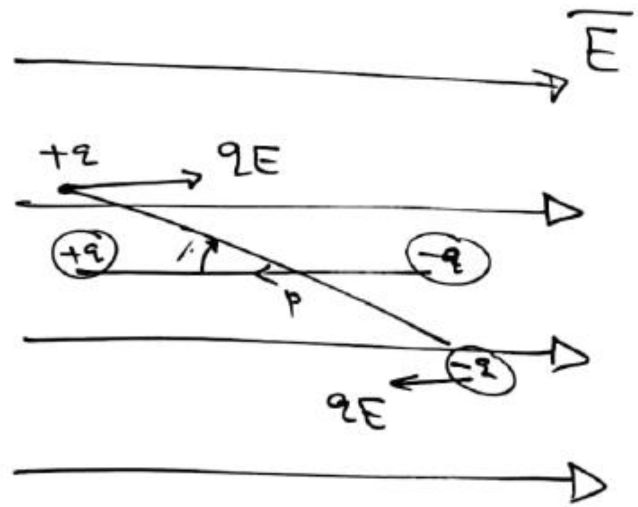


Equilibrium [$\theta = 0$, $\theta = 180$]

$\boxed{\tau = 0,\ F = 0}$ $\quad$ $\boxed{\theta} \rightarrow \underline{180}$ [Unstable equilibrium]

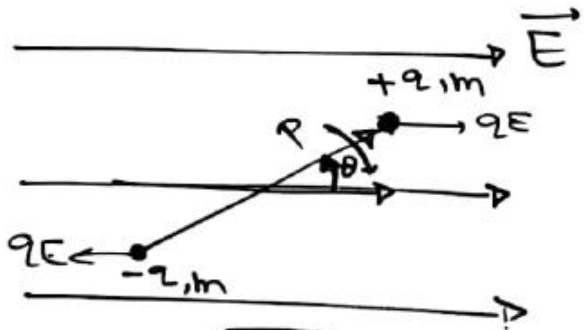
(i) $\underline{\theta = 0}$ [Stable equilibrium] :





Time period of Electric dipole in uniform Electric field.

$\vec{\tau} \propto -\vec{\theta}$



For S.H.M

$\vec{F} \propto -\vec{x}$	$\vec{\tau} \propto -\vec{\theta}$

$\tau = PE\sin\theta$ $[\theta \to \text{small } \sin\theta \simeq \theta]$

$\tau = PE\theta$

$\boxed{\vec{\tau} = -PE\vec{\theta}}$

$\tau = I\alpha$

$\tau = I\alpha$

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

$\Downarrow$

$\omega^2\theta$

$-PE\theta = I\alpha$

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

$-\omega^2\theta = -\frac{PE}{I}\theta$

$\omega^2 = \frac{PE}{I}$

$\omega = \sqrt{\frac{PE}{I}}$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{PE}{I}}}$

$\boxed{T = 2\pi\sqrt{\frac{I}{PE}}}$

ABLES KOTA

#

$\vec{F} \propto -\vec{x}$ [S.H.M]

$\boxed{\vec{a} = -\omega^2 \vec{x}}$

$F = -kx$

$\boxed{a = -\frac{k}{m}x}$

$-\frac{k}{m}x = -\omega^2 x$

$\omega^2 = \frac{k}{m}$ $\quad \omega = \sqrt{\frac{k}{m}}$

$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$

[$\vec{\tau} \propto -\vec{\theta}$]

$\boxed{\alpha = -\omega^2 \theta}$

angular S.H.M

$\frac{\tau}{I} = -\omega^2\theta$

$-\frac{PE\theta}{I} = -\omega^2\theta$

$\omega^2 = \frac{PE}{I}$

$\omega = \sqrt{\frac{PE}{I}}$ $\quad T = 2\pi\sqrt{\frac{I}{PE}}$