DPP-9

Dipole

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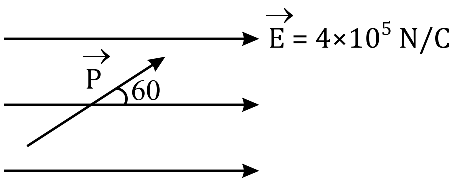
1. $\tau = PE\sin\,\theta$

$8\sqrt{3} = P.4 \times 10^5 \times \frac{\sqrt{3}}{2}$



$P = 4 \times 10^{-5} c - m$

$q \times d = 4 \times 10^{-5} C - m = q \times 4 \times 10^{-2} = 4 \times 10^{-5} C - m$

$q = 10^{-3} C \Rightarrow q = 1 mC$

2. $q_A = 2.5 \times 10^{-7} C = q_B = -2.5 \times 10^{-7} C$

$\vec{A} = -15\hat{k}$ cm

$\vec{B} = 15\hat{k}$ cm

direction of dipole moment is negative to positive charge

$\overrightarrow{BA} = -30 \times 10^{-2}\hat{k} - m$

$\vec{P} = q \cdot \overrightarrow{BA}$

$\vec{P} = -2.5 \times 10^{-7} \times 30 \times 10^{-2}\hat{k}\ c - m$

$\vec{P} = -7.5 \times 10^{-8}\hat{k}\ c - m$

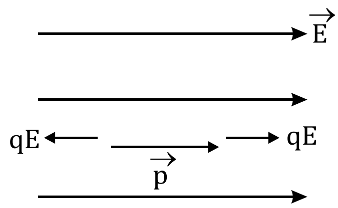
$\overrightarrow{AB} = 3 \times 10^{-1} m\hat{k}$

$\vec{p} = q\,\overrightarrow{BA}$

$\boxed{\vec{p} = -7.5 \times 10^{-8} c - m\,\hat{k}}$

q_{net} of the system = 0

3. Angle (θ) between $\vec{E}$ & $\vec{p}$ is zero



$F = 0$

Net Force on dipole in uniform electric field always zero

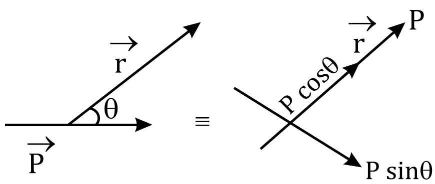
$U = -PE\cos\theta$ [Assume $U_{90} = 0$]

$U = -PE$

that's mean Force is zero & Potential Energy is minimum.

4. Potential due to $P\cos\,\theta$

$\frac{k\,P\cos\,\theta}{r^2} = \frac{k\,P\,r\cos\,\theta}{r^3} = \frac{k\,\vec{p} \cdot \vec{r}}{r^3}$



& Potential due to P sinθ at Point P is zero because

Point P behave equitorial Point for P sin θ.

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5. $\vec{P} = (-\hat{\imath} - 3\hat{\jmath} + 2\hat{k}) \times 10^{-29} c - m$

$\vec{r} = \hat{\imath} + 3\hat{\jmath} + 5\hat{k}$

give $\vec{p} \cdot \vec{r} = 0$

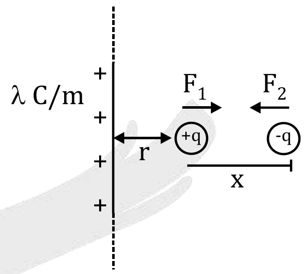
that's mean $\vec{p} \perp \vec{r}$

$\vec{E} = \dfrac{-k\vec{p}}{r^3}$ [For equatorial point]

$\hat{E} = -\hat{p}$

di r^r of $\vec{E}$ parallel to $= (\hat{\imath} + 3\hat{\jmath} - 2\hat{k})$

6. $F_1 = \frac{2k\lambda q}{r}$ $\quad F_2 = \frac{2k\lambda q}{x+x}$

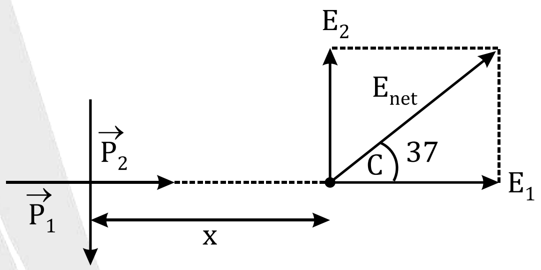


$F_{net} = F_1 - F_2 = \dfrac{2k\lambda q \cdot x}{r(r+x)}$

$4 = \dfrac{2 \times 9 \times 10^9 \times 3 \times 10^{-6} \times 2 \times 10^{-3}, q}{10 \times 10^{-3} \times 12 \times 10^{-3}}$

$q = 4.44 \times 10^{-6} C$

7. $E_1 = \frac{2kp_1}{x^3}$



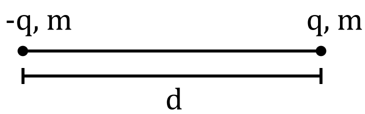
$E_2 = \dfrac{KP_2}{x^3} = \tan\ 37 = \dfrac{E_2}{E_1}$

$\dfrac{3}{4} = \dfrac{kP_2}{x^3 \cdot \dfrac{2kP_1}{x^3}} = \dfrac{3}{4} = \dfrac{P_2}{2p_1}$

$\dfrac{P_1}{P_2} = \dfrac{2}{3}$

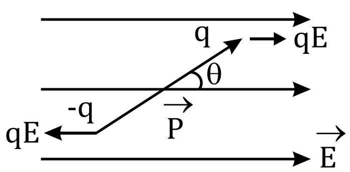
8. $\tau = PE\sin\ \theta$

$\tau = qdE\sin\ \theta$ $\qquad$ $(\sin\ \theta \simeq \theta)$ bczθ is very small



$I\alpha\ = qdE\theta$

$\alpha\ = \dfrac{qdE}{I}\theta \Rightarrow I = \dfrac{md^2}{4} + \dfrac{md^2}{4} = \dfrac{md^2}{2}$



$\alpha\ = \dfrac{2qEd}{md^2}\theta = \dfrac{2qE}{md}\theta \Rightarrow \alpha = -\omega^2\theta$

Restoring Torque at opposite to axial displacement vector

$\alpha = \dfrac{-2qE}{md} = -\omega^2\theta \Rightarrow \omega = \sqrt{\dfrac{2qE}{md}}$

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9. $\tau = PE\sin\,\theta$

$\theta = 90$

τ_{max}

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

$\vec{E}_{equatorial} = \frac{-k\vec{p}}{r^3} = \frac{E_{axial}}{E_{equatorial}} = \frac{-2}{1}$

But in magnitude $= \frac{2}{1}$

11. In non uniform electric field

Case I $E_1 > E_2$

$F_1 > F_2$

$F_{net} \neq 0$

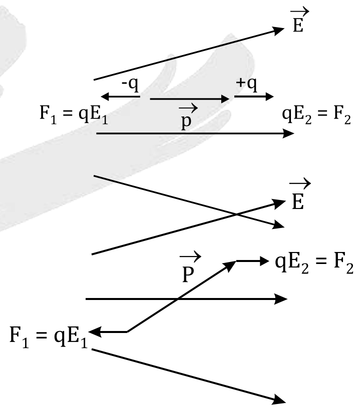
$\tau = 0$

Case II $F_1 > F_2$

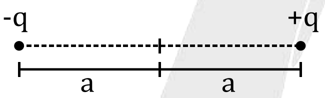
$F_{net} \neq 0$

$\tau = 0$

Torque may or may not be zero.



12.



$E \neq 0 \qquad V = 0$

13. $q = 3.2 \times 10^{-19}C$

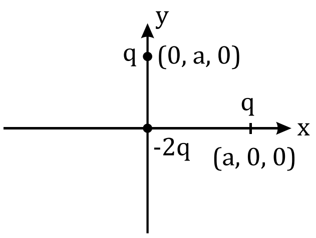
$d = 2.4 \times 10^{-10}m$

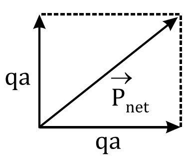
$P = qd = 3.2 \times 10^{-19} \times 2.4 \times 10^{-10} = 7.68 \times 10^{-29}C - m$

14. $q \rightarrow (0, a, 0)\ -2q \rightarrow (0,0,0)$

$q \rightarrow (a, 0,0)$

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





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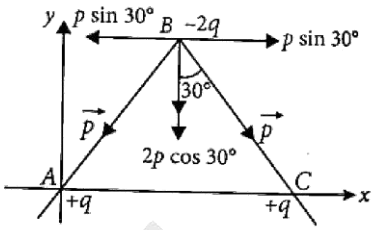
15. Electric field due to dipole on equatorial plane, $\vec{E} = -k\frac{\vec{p}}{r^3}$

At point P, $\vec{F}_P = -k\frac{\vec{p}}{y^3}Q$ (1)

At point P′, $\vec{F}_{P'} = -\left(-k\frac{\vec{p}}{(y/3)^3}Q\right)$ (2)

From equation (i) and (ii), $\vec{F}_{P'} = 27\vec{F}_P = 27\vec{F}$

16. The given system of charges can be considered as two dipoles as shown. Let p be the dipole moment of the dipole. The horizontal components of $\vec{p}$ cancels each other and vertical components adds up.



So, the net dipole moment of system of charges,

$$2\,\text{pcos}\,30°(-\hat{j}) = 2(ql)\left(\frac{\sqrt{3}}{2}\right)(-\hat{j}) = -\sqrt{3}ql\,\hat{j}$$

17. Dipole moment of fixed dipole can be written as $\vec{p} = p\cos\theta\hat{i} + p\sin\theta\hat{j}$;

For electric field $\vec{E}_1 = E\hat{i}$

Torque on the dipole, $\vec{T}_1 = (\vec{p} \times \vec{E}_1)\vec{T}_1 = (p\cos\theta\hat{i} + p\sin\theta\hat{j}) \times (E\hat{i})\ \vec{T}_1 = pE\sin\theta(-\hat{k})$;

Now for $\vec{E}_2 = \sqrt{3}E_1\hat{j} = \sqrt{3}E\hat{j}$ In this case,

torque on the dipole $\vec{T}_2 = (p\cos\theta\hat{i} + p\sin\theta\hat{j}) \times (\sqrt{3}E\hat{j}); \vec{T}_2 = \sqrt{3}pE\cos\theta(\hat{k})$

Now given, $\vec{T}_2 = -\vec{T}_1\ \sqrt{3}pE\cos\theta(\hat{k}) = -pE\sin\theta(-\hat{k})\sqrt{3}\cos\theta = \sin\theta$

or $\frac{\sin\theta}{\cos\theta} = \sqrt{3}; \tan\theta = \sqrt{3} \Rightarrow \theta = 60°$

18. $q = 4 \times 10^{-8}C$

$d = 2 \times 10^{-4}m$

$E = 4 \times 10^{8}N/C$

$\tau_{max} = PE$

$= (4 \times 10^{-8} \times 2 \times 10^{-4})4 \times 10^{8}$

$= 32 \times 10^{-4}N - m$

$W = PE(\cos\theta_1 - \cos\theta_2)$

$= 8 \times 10^{-12} \times 4 \times 10^{8}[\cos\theta - \cos 180]$

$= 32 \times 10^{-4}[1 - (-1)]$

$= 64 \times 10^{-4}J$

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19. $W = PE(\cos\theta_1 - \cos\theta_2)$

$= PE[1 - 0]$

$= PE$