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Section: 09

Data of Assignment 1.1

$q_1 = 3\ mC$; $q_2 = -6\ mC$; coordinates = $(-4,4)$, $(4,1)$

$q_0 = +2.5\ \mu C$; mass of $q_0 = 1\ gm$

Data of Assignment 1.2

$L = 131\ m$, $\lambda_A = 4.0 \times 10^{-2}\ C/m$

$r = 2.0\ cm$, * distance vector makes angle $= 90°$.

* another charged rod at distance $d = 4.0\ cm$

* dipole makes angle with $\hat{i} = 59°$

* $q = 469e$; $s = 26.0\ \mu m$;

$I = 1 \times 10^{-15}\ kgm^2$

Assignment 1.1

a) $\vec{r} = \vec{r}_2 - \vec{r}_1 = (4\hat{i} + 1\hat{j}) - (-4\hat{i} + 4\hat{j})$

$= 4\hat{i} + 1\hat{j} + 4\hat{i} - 4\hat{j}$

$= 8\hat{i} - 3\hat{j}$

Here,
$q_1 = 3\,mC$
$(-4, 4)$
$q_2 = -6\,mC$
$(4, 1)$

and, $|\vec{r}| = \sqrt{8^2 + (3)^2} = \sqrt{64 + 9} = \sqrt{73}$

$\therefore \hat{r}_{12} = \dfrac{8\hat{i} - 3\hat{j}}{\sqrt{73}} = 0.94\hat{i} - 0.35\hat{j}$ (Ans)

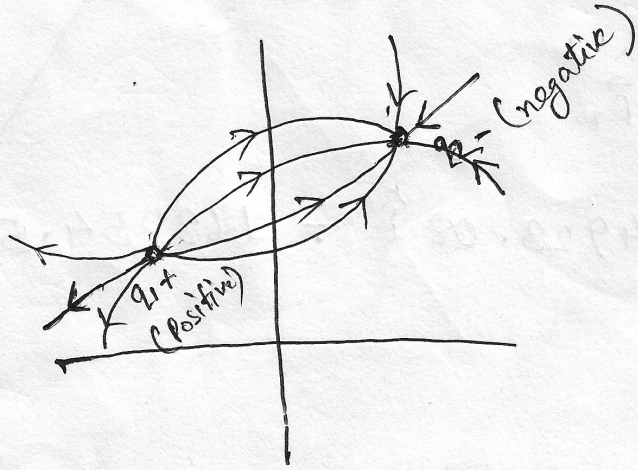
b) $\vec{F}_{12} = k \cdot \dfrac{q_1 q_2}{r^3} \vec{r}$ Here, $q_1 = 3mC$, $q_2 = -6mC$

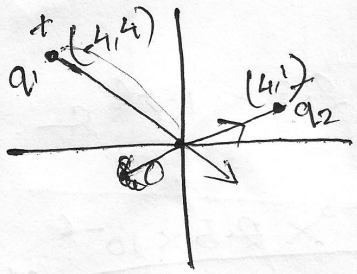
$= 8.987 \times 10^9 \times \dfrac{3 \times 10^{-3} \times (-6) \times 10^{-3}}{(\sqrt{73})^3} \times \cancel{(0.94\hat{i} - 0.35\hat{j})}$ $(8\hat{i} - 3\hat{j})$

$= \cancel{-2083.01\hat{i} + 775.59\hat{j}}$

$= -2074.88\hat{i} + 778.08\hat{j}$ (Ans)

c)





$q_1 = 3\,mC$

$q_2 = -6\,mC$

~~$q_0 = 2.5\,\mu C$~~

$$\therefore \vec{E}_{10} = 8.987 \times 10^9 \times \frac{3 \times 10^{-3}}{(\sqrt{32})^3} \times (+4\hat{i} - 4\hat{j})$$

$$= 595759.56\,\hat{i} - 595759.56\,\hat{j}$$

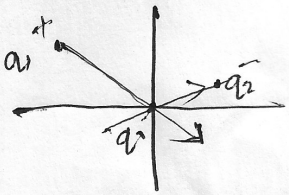
Again, $\vec{E}_{20} = 8.987 \times 10^9 \times \frac{-6 \times 10^{-3}}{(\sqrt{17})^3} \times (-4\hat{i} - 1\hat{j})$

$$= 3077177.88\,\hat{i} + 769294.47\,\hat{j}$$

$$\therefore \vec{E}_{net} = \vec{E}_{10} + \vec{E}_{20}$$

$$= 3672937.44\,\hat{i} + 173534.91\,\hat{j}$$

e)



$q_1 = 3\,mC$

$q_2 = -6\,mC$

$q_0 = 2.5\,\mu C$

from qstn (d), we got,

$$\vec{E}_{net} = 3672937.44\,\hat{i} + 173534.91\,\hat{j}$$

$$\therefore \vec{F}_{net} = 2.5 \times 10^{-6} \times (\vec{E}_{net}) \quad [\because E = \frac{F}{q}]$$

$$= 9.18\,\hat{i} + 0.43\,\hat{j}$$

(Ans)

(f) We know, $\vec{F} = m\vec{a}$

$$\therefore \vec{a} = \frac{\vec{F}}{m} = \frac{9.18\,\hat{i} + 0.43\,\hat{j}}{1 \times 10^{-3}}$$

$$= 9180\,\hat{i} + 430\,\hat{j}$$

~~g) Now, $\vec{F}_{gq_0} = 1 \times 10^{-3} \times 9.8$~~

~~$= 9.8 \times 10^{-3}$~~

~~$\therefore \vec{F}_y = 0.43 - (9.8 \times 10^{-3})$~~

~~$= 0.42$~~

~~(Ans)~~

g) From (e), we get y component = 0.43

Now, magnitude of gravitational force on q_0

$$= \frac{GMm}{R^2} = \frac{6.67 \times 10^{-11} \times 5.972 \times 10^{24} \times 0.001}{(6400000)^2}$$

$$= 0.00972 \approx 0.01.$$

(Ans)

Since, ~~magni~~ $0.01 < 0.43$, electric force can counter gravitational force.

Assignment 1.2

a) The formula for electric field from a charged rod of finite length is

$$E = \frac{2kQ}{r\sqrt{4r^2+L^2}}$$

Here, r = distance of the charge from rod
L = length of the rod.

According to the Question, the electric field will only occur in the x axis.

$\therefore \vec{E}_y = 0$ and,

$$\vec{E}_x = \frac{2 \times 8.987 \times 10^9 \times 131 \times 4 \times 10^{-2}}{0.02 \times \sqrt{4 \times (0.02)^2 + (131)^2}} \hat{i}$$

$$\approx 35948.00 \times 10^6$$

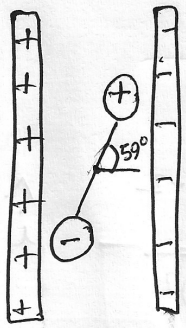
b) If there is another negatively charged rod just at the opposite of the positive rod and parallel with it, then the

electric field at the middle point between them will exactly be the twice of the previous electric field and in the same direction.

$$\therefore \vec{E}_x = 2 \times \cancel{71896.00}\ 35948.00 \times 10^6 = 71896.00 \times 10^6\ \hat{i}$$

$$\vec{E}_y = 2 \times 0 = \cancel{2}\ 0\hat{j}$$

c)



d) We know,

$$|P| = q \times r = 469 \times 1.6 \times 10^{-19} \times 26 \times 10^{-6}$$

$$= 1951.04 \times 10^{-24}$$

Now,

$$P_x = |P|\cos\theta = 1951.04 \times 10^{-24} \times \cos(59^\circ)\,\hat{i}$$
$$= 1004.86 \times 10^{-24}\,\hat{i}$$

$$P_y = |P|\sin\theta = 1951.04 \times 10^{-24} \times \sin(59^\circ)\,\hat{j}$$
$$= 1672.37 \times 10^{-24}\,\hat{j}$$

e) Here the net electric force on the dipole will be 0.

And we know, $\tau = \vec{F} \times r \times \sin\theta$

$$= \vec{E} \times q \times r \times \sin\theta$$
$$= 71896 \times 469 \times 1.6 \times 10^{-9} \times 26 \times 10^{-6} \times \sin(59^\circ) \times 10^{6}$$
$$= 120.24 \times 10^{-12}\ \text{N.m}$$

(f) We know, $\alpha = \dfrac{\tau}{I} = \dfrac{120.24 \times 10^{-12}}{1 \times 10^{-15}}$

$$= 120236.55\ \text{rad/s}^2$$