1 Id: 20101239

Physics 112

Assignment 1.1

GA 1.1

(a)

$\vec{r}_1 = (-20, 50, 44)$

$\vec{r}_2 = \left(\frac{36}{\sqrt{3}}, \frac{36}{\sqrt{2}}, -31\right)$

$\therefore \vec{r} = r_2 - r_1$

$= \left(+20 + \frac{36}{\sqrt{3}}\right) \times 10^{-9}\,\hat{i} + \left(-50 + \frac{36}{\sqrt{2}}\right) \times 10^{-9}\,\hat{j} +$

$(-44 - 31) \times 10^{-9}\,\hat{k}$

$= 40.7846 \times 10^{-9}\,\hat{i} - 24.5441 \times 10^{-9}\,\hat{j}$

$-75 \times 10^{-9}\,\hat{k}$

2

(b)

$\vec{r}_{12} = r_1 - r_2 = -30.7846 \times 10^{-9}\hat{i} + 24.5441 \times 10^{-9}\hat{j} + 75 \times 10^{-9}\hat{k}$

$\therefore |r| = 8.883 \times 10^{-8}$

$r^3 = 7.00937 \times 10^{-22}$

$\therefore f_{12} = \dfrac{k.q_1 q_2}{r^3}\vec{r}$

$= \dfrac{8.987 \times 10^9 \times 32 \times 34 \times (-1.60217329 \times 10^{-19})^2}{7.00937 \times 10^{-22}}\vec{r}$

$= 3.584 \times 10^{-4} \times \vec{r}$

$= -1.1603 \times 10^{-11}\hat{i} + 8.7892 \times 10^{-12}\hat{j} + 2.68575 \times 10^{-11}\hat{k}$

3 c

$q_1 = 32e$

$q_3 = 12e$

$\vec{r}_{31} = \vec{r}_1 - \vec{r}_3$

$= (-20, 50, 45) - \left(-\frac{37}{\sqrt{3}}, \frac{41}{\sqrt{2}}, -22\right)$

$= \left(1.6319\,\hat{i} + 21.0086\,\hat{j} + 66\hat{k}\right)\ nm$

$= \left(1.6319 \times 10^{-9}\,\hat{i} + 21.0086 \times 10^{-9}\,\hat{j} + 66 \times 10^{-9}\,\hat{k}\right) m$

$|\vec{r}| = 6.9282 \times 10^{-8}$

$|\vec{r}|^3 = 3.3255 \times 10^{-22}$

$\therefore$

$$\therefore \vec{F}_{31} = 8.987\times10^{9} \times \frac{32\times(-12)\times(-1.60217662\times10^{-19})^2}{r^3} \times \vec{r}$$

$$= -2.6638\times10^{-4} \times \vec{r}$$

$$= -4.347\times10^{-13}\hat{i} - 5.59627\times10^{-12}\hat{j} - 1.7581\times10^{-11}\hat{k}$$

$$\therefore \vec{F} = \vec{F}_{31} + \vec{F}_{21}$$

$$= -1.50387\times10^{-11}\hat{i} + 3.19293\times10^{-12}\hat{j}$$

$$+ 9.2765\times10^{-12}\hat{k}$$

5

(d)

$$\vec{r}_{12} = \vec{r}_2 - \vec{r}_1$$

$$= 4.07856 \times 10^{-8}\,\hat{i} - 2.45551 \times 10^{-8}\,\hat{j}$$

$$- 75 \times 10^{-9}$$

$$\therefore |\vec{r}| = 8.883 \times 10^{-8}$$

$$r^3 = 7.009 \times 10^{-22}$$

2

$$\vec{r}_{32} = \vec{r}_2 - \vec{r}_3$$

$$= \left(\frac{36}{\sqrt{3}} + \frac{37}{\sqrt{3}}\right) \times 10^{-9}\,\hat{i} + \left(\frac{36}{\sqrt{2}} - \frac{41}{\sqrt{2}}\right) \times 10^{-9}\,\hat{j}$$

$$+ (-31 + 22) \times 10^{-9}\,\hat{k}$$

$$= 42.1466 \times 10^{-9} - 3.5355 \times 10^{-9}\,\hat{j} - 9 \times 10^{-9}\,\hat{k}$$

$$\therefore |\vec{r}|_{32} = 4.3241 \times 10^{-8}$$

$$\therefore (\vec{r})^3_{32} = 8.0851 \times 10^{-23}$$

$$\therefore \vec{F}_{32} = k \cdot \frac{q_2 \cdot q_3}{r^3_{32}}\, \vec{r}_{32}$$

$$= \frac{8.987 \times 10^{9} \times 34 \times (-12) \times (-1.60217662 \times 10^{-19})^2}{8.0851 \times 10^{-23}} \times \vec{r}$$

$$= -1.164 \times 10^{-3} \times \vec{r}_{32}$$

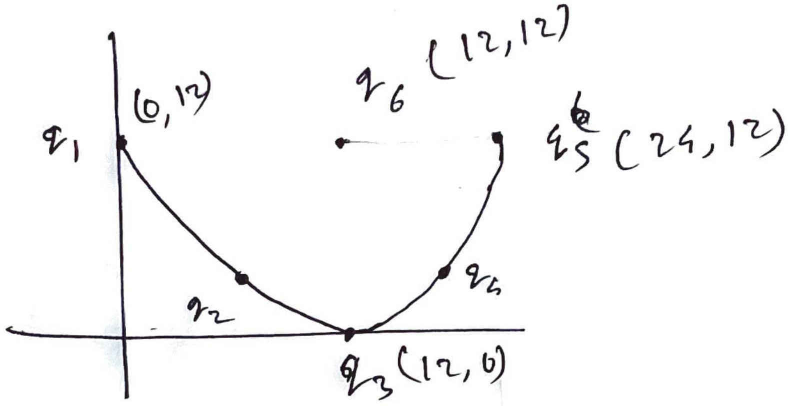
$$= -4.9058 \times 10^{-11}\,\hat{i} + 4.1158 \times 10^{-12}\,\hat{j} + 1.0476 \times 10^{-11}\,\hat{k}$$

$$\therefore \vec{F}_2 = \vec{F}_{12} + \vec{F}_{32}$$

$$= -3.45531\times10^{-11}\,\hat{i} - 4.67395\times10^{-12}\,\hat{j}$$

$$-1.63815\times10^{-11}\,\hat{k}$$

Ans to the Q; N; 1.2



(a)

$\vec{r}_1 = 0\hat{i} + 12\hat{j}$

$\vec{r}_6 = 12\hat{i} + 12\hat{j}$

$\therefore \vec{r}_{16} = \cancel{\vec{A}_1} \; \vec{r}_6 - \vec{r}_1$

$= (-12\hat{i} + 0\hat{j})$ cm

$= (0.12\hat{i} + 0\hat{j})$ m

(b)

$$\vec{F}_{16} = \frac{k \cdot q_1 q_6 \cdot \vec{r}_{16}}{|\vec{r}|^3}$$

$$= \frac{8.987\times10^9 \times (23\times10^{-6}) \times (-36\times10^{-6})}{\left(\sqrt{(0.12)^2}\right)^3} \vec{r}_{16}$$

$$= -4306.27 \times (-0.12\hat{i} + 0\hat{j})$$

$$= -516.7525\hat{i} + 0\hat{j}$$

(c)

$\vec{r}_3 = 12\hat{i} + 0\hat{j}$

$\vec{r}_6 = 12\hat{i} + 12\hat{j}$

$\therefore$ ~~$\vec{r}_{36} = (0\hat{i} - 12\hat{j})$ cm~~

~~$= (0\hat{i} - 0.12\hat{j})$ m~~

$\therefore \vec{r}_{36} = \vec{r}_6 - \vec{r}_3$

$= (0\hat{i} + 12\hat{j})$ cm

$= (0\hat{i} + 0.12\hat{j})$ m

(d)

$$|\vec{r}_{36}| = 0.12$$

$$(\vec{r}_{36})^3 = 1.728 \times 10^{-3}$$

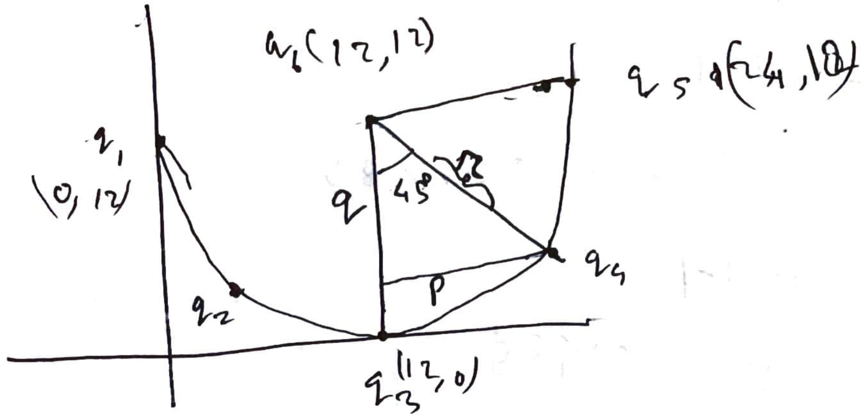
$$\therefore \vec{F}_{36} = k \cdot \frac{q_3 q_6 \vec{r}_{36}}{|\vec{r}_{36}|^3}$$

$$= 8.987 \times 10^9 \times \frac{-36 \times 10^{-6} \times -36 \times 10^{-6}}{1.728 \times 10^{-3}} \vec{r}_{36}$$

$$= 6740.25 \times (0\hat{i} + 0.12\hat{j})$$

$$= 0\hat{i} + 808.83\hat{j}$$

(e)



Let, coordinate of $q_4(x, y)$.

In the triangle,

$$\cos 45° = \frac{p}{12}$$

$$\therefore p = 8.485$$

Again,

$$\sin 45° = \frac{q}{12}$$

$$\therefore q = 8.485$$

~~So, q_4(8.485,~~

$\therefore x = r + q$

$= 12 + 8.485$

$= \cancel{3.515}\ 20.485$

$\therefore y = r - p$

$= 12 - 8.485$

$= \cancel{20.485}\ 3.515$

$\therefore \vec{R}_{4,6} = \vec{r}_6 - \vec{r}_4$

$\cancel{= 12, 12}$

$= (12\hat{i} + 12\hat{j}) - (3.515\hat{j} + 20.485\hat{i})$

$\cancel{= (8.485\hat{i} + 32.485\hat{j})\ cm}$

$\cancel{= 0.08485\hat{i} + 0.32485\hat{j}}$

$= (8.485\hat{j} + -8.485\hat{i})\ cm$

$= (-0.08485\hat{i} + 0.08585\hat{j})\ m$

(f)

$|\vec{r}_{4,6}| = 0.11999$

$|\vec{r}_{4,6}|^3 = 1.72786 \times 10^{-3}$

$\therefore \vec{F} = k_e \dfrac{q_4 \cdot q_6}{|\vec{r}|^3} \times \vec{r}$

$= 8.987 \times 10^9 \times \dfrac{16 \times (-36) \times (10^{-6})^2}{1.7276 \times 10^{-3}} \times \vec{r}$

$= -2996.36 \times (-0.08485\hat{i} + 0.08485\hat{j})$

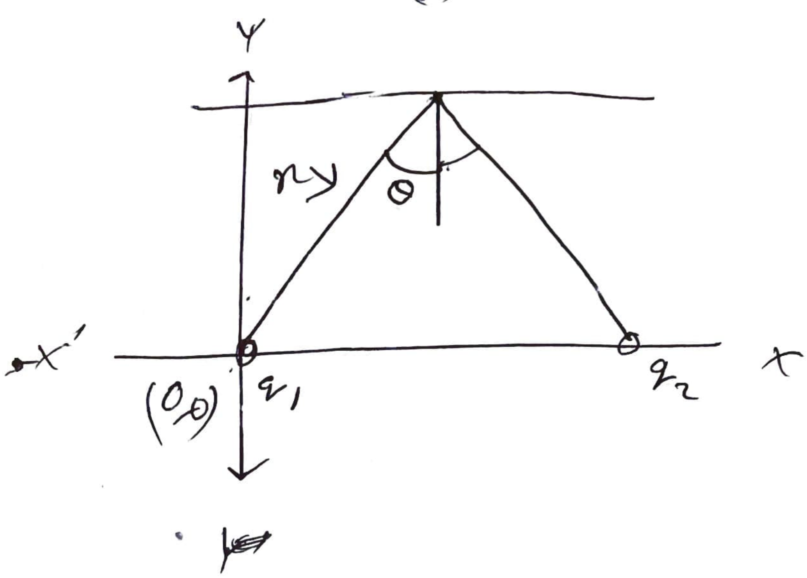
$= 254.241\hat{i} - 254.241\hat{j}$

(g)

$$\vec{F}_6 = \vec{F}_{16} + \vec{F}_{26} + \vec{F}_{2c} + \vec{F}_{36} + \vec{F}_{46} + \vec{F}_{56}$$

Ans to the Q: N: 1.3

(a)



Here,

$x = 10\ cm = 0.10\ m$

$L = 248\ cm$

$q = 60\ nC$

We know,

$$x = \left(\frac{q^2 L}{2\pi \epsilon_0 m g}\right)^{\frac{1}{3}}$$

$$\Rightarrow m = \frac{q^2 L}{2\pi \epsilon_0 g x^3}$$

$$= \frac{(60\times10^{-9})^2 \times 248}{2\times\pi\times8.854\times10^{-12}\times9.8\times(0.10)^3}$$

$$= 0.016\cancel{0}6 \quad m$$

(b)

Because of discharging sphere 2,

$q_2' = 0$

0

sphere 1's charge, $q_1 = \left(\frac{60 \times 10^{-9}}{2}\right) C$

$= 3 \times 10^{-8}\ C$

sphere 2's " $q_2 = 3 \times 10^{-8}\ C$

1(c)

For,

$$q_1 = q_2 = 3\times10^{-8}\,C$$

$$\frac{F_y}{F_x} = \frac{F_{21}}{F_g}$$

$$\Rightarrow \frac{F\sin\theta}{F\cos\theta} = \frac{F_{21}}{F_g}$$

$$\therefore \tan\theta = \frac{kq^2}{mgx^2}$$

Now,

$\tan\theta = \sin\theta$ [$\because \theta$ is very small]

$$\therefore \sin\theta = \frac{x/2}{L}$$

$$\Rightarrow \frac{x}{2L} = \cancel{kq}\ \cancel{kq}\ \frac{kq^2}{mg\cancel{x}^2}$$

$$\Rightarrow x^3 = \frac{2kq^2L}{mg}$$

$$\therefore x = \frac{2\times8.987\times10^9\times(3\times10^{-8})^2\times2.48}{0.01\times9.8}$$

$$= 0.0634$$

(f)

$$r' = \left(\frac{k q^2 L}{m g} \right)^{\frac{1}{3}}$$

$$= \left(\frac{8.987 \times 10^9 \times (60 \times 10^{-9})^2 \times 2.48}{0.016 \times 9.8} \right)^{\frac{1}{3}}$$

$$= 0.08 \text{ m}$$

(d)

$$\vec{F}_{2,1} = \frac{k q_2 q_1}{4 r^2}$$

$$= \frac{8.987 \times 10^9 \times (60 \times 10^{-9})^2}{4 \times (0.08)^2}$$

$$= 1.26 \times 10^{-3}$$

c)

$$\vec{F}_{3,1} = \frac{k q_3 q_1}{4r^2}$$

$$= \frac{8.987\times10^{9} \times (60\times10^{-9})^2}{4\times0.08^2}$$

$$= 1.26\times10^{-3}$$