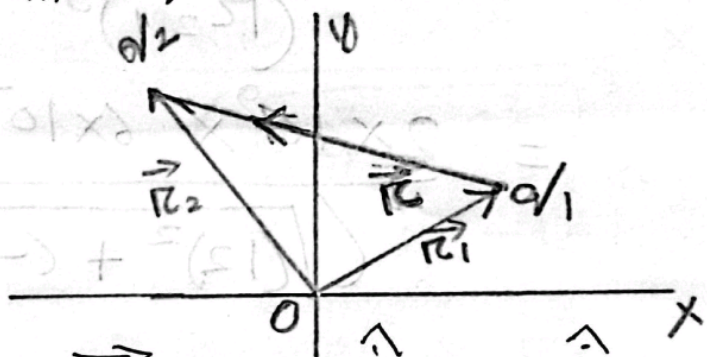
$\frac{13}{13}$ Ans. to. the. Q. No - 1

Given,

$$q_1 = 6\,\mu C$$
$$= 6 \times 10^{-6} C$$
$$q_2 = 12\,\mu C$$
$$= 12 \times 10^{-6} C$$

Points are (6, 4) and (-6, 10)

We know, $K = 9 \times 10^9\ Nm^2/C^2$



$$\therefore \vec{r}_1 = 6\hat{i} + 4\hat{j} \quad \ldots (I)$$
$$\vec{r}_2 = -6\hat{i} + 10\hat{j} \quad \ldots (II)$$

$$\vec{r}_{1,2} = \vec{r}_2 - \vec{r}_1$$
$$= -6\hat{i} + 10\hat{j} - 6\hat{i} - 4\hat{j}$$
$$= -12\hat{i} + 6\hat{j}$$

$$\vec{r}_{2,1} = \vec{r}_1 - \vec{r}_2$$
$$= 6\hat{i} + 4\hat{j} + 6\hat{i} - 10\hat{j}$$
$$= 12\hat{i} - 6\hat{j}$$

$$\vec{F}_{1,2} = \frac{K \times q_1 q_2}{(r_{1,2})^3} \times \vec{r}_{1,2} \quad \left[|r_{1,2}| = \sqrt{(-12)^2 + 6^2} \right.$$

$$= \frac{9\times10^9 \times 6\times10^{-6} \times 12\times10^{-6}}{\left(\sqrt{(-12)^2+6^2}\right)^3}$$

$$= 2.68 \times 10^{-4} (-12\hat{i} + 6\hat{j})$$

$$\vec{F}_{2,1} = \frac{K \times q_1 \times q_2 \times \vec{r}_{2,1}}{(r_{2,1})^3}$$

$$= \frac{9\times10^9 \times 6\times10^{-6} \times 12\times10^{-6}}{\left(\sqrt{(12)^2+(-6)^2}\right)^3} \times (12\hat{i} - 6\hat{j})$$

$$\left[r_{2,1} = \sqrt{12^2 + (-6)^2} \right.$$

$$= 2.68 \times 10^{-4} (12\hat{i} - 6\hat{j})$$

The x and y components of $\vec{F}_{1,2}$ and $\vec{r}_{1,2}$ are,

$$F_{x1,2} = -12 \times 2.68\times10^{-4} = -3.21\times10^{-3}\,N$$

$$F_{y1,2} = 6 \times 2.68\times10^{-4} = 1.6\times10^{-3}\,N$$

$$r_{x1,2} = -12$$

$$r_{y1,2} = 6$$

The x, y components of $\vec{F}_{2,1}$ and $\vec{r}_{2,1}$ are,

$$F_{x_{2,1}} = 12 \times 2.68 \times 10^{-4} = 3.21 \times 10^{-3} N$$

$$F_{y_{2,1}} = -6 \times 2.68 \times 10^{-4} = -1.608 \times 10^{-3} N$$

$$r_{x_{2,1}} = 12$$

$$r_{y_{2,1}} = -6$$

Now,

$$\vec{E}_{1,2} = \frac{k \times q_1 \times \vec{r}_{1,2}}{(|r_{1,2}|)^3}$$

$$= \frac{9 \times 10^9 \times 6 \times 10^{-6}}{(\sqrt{(-12)^2 + 6^2})^3} \times (-12\hat{i} + 6\hat{j})$$

$$= 22.36(-12\hat{i} + 6\hat{j}).$$

$$\vec{E}_{2,1} = \frac{k \times q_2 \times \vec{r}_{2,1}}{(|r_{2,1}|)^3}$$

$$= \frac{9 \times 10^9 \times 12 \times 10^{-6}}{(\sqrt{(12)^2 + (-6)^2})^3} \times (12\hat{i} - 6\hat{j})$$

$$= 44.72(12\hat{i} - 6\hat{j})$$

We know that,

$$\vec{F}_{1,2} = q_2 \times \vec{E}_{1,2}$$

$$= 12\times10^{-6} \times 22.36(-12\hat{i}+6\hat{j})$$

$$= 2.6832\times10^{-4}(-12\hat{i}+6\hat{j})\,N$$

$$\vec{F}_{2,1} = q_1 \times \vec{E}_{2,1}$$

$$= 6\times10^{-6} \times 44.72(12\hat{i}-6\hat{j})$$

$$= 2.6832\times10^{-4}(12\hat{i}-6\hat{j})$$

$$= -2.6832\times10^{-4}(-12\hat{i}+6\hat{j})$$

$$\therefore \vec{F}_{2,1} = -\vec{F}_{1,2}$$

Or $\vec{F}_{1,2} = -\vec{F}_{2,1}$

This implies that if $\vec{F}_{1,2}$ represents a force applied in a certain direction, $\vec{F}_{2,1}$ represents an equal force applied in the exact opposite directions. In short, magnitudes of $\vec{F}_{1,2}$ and $\vec{F}_{2,1}$ are same but they act in opposite direction. The result will also be the same when we use coulombs law

Ans. to the Q. No - 2

(a) Given,

$$q_0 = -10\ nC$$

$$Q_1 = Q_2 = 20\ \mu C$$

Now,

$$F_{1,0} = K \frac{q_0 Q_1}{r_1^2}$$

$$F_{2,0} = K \frac{q_0 Q_2}{r_2^2}$$

We know, when q_0 is in equilibrium,

$$F_{1,0} = F_{2,0}$$

$$\Rightarrow K \times \frac{q_0 Q_1}{r_1^2} = K \times \frac{q_0 \times Q_2}{r_2^2}$$

$$\Rightarrow \frac{Q_1}{r_1^2} = \frac{Q_2}{r_2^2}$$

$$\Rightarrow \frac{r_2^2}{r_1^2} = \frac{Q_2}{Q_1} \quad \ldots (1)$$

$$\Rightarrow \frac{r_2^2}{r_1^2} = 1 \qquad [Q_2 = Q_1]$$

$$\Rightarrow r_2^2 = r_1^2$$

$$\therefore r_2 = r_1$$

so, if r_1 is 1cm then r_2 will be 1cm.

A slight deviation from the middle will make q_0 go toward the closer charge due to attractive force.

(6) From eqn (1), we get

$$\frac{r_2^2}{r_1^2} = \frac{Q_2}{Q_1}$$

[Given, $Q_1 = 10\mu C$, $Q_2 = 30\mu C$]

$$\Rightarrow \frac{r_2^2}{r_1^2} = \frac{30}{10}$$

$$\Rightarrow \left(\frac{r_2}{r_1}\right)^2 = 3$$

$$\Rightarrow \frac{r_2}{r_1} = \sqrt{3}$$

$$\Rightarrow r_2 = \sqrt{3}\, r_1$$