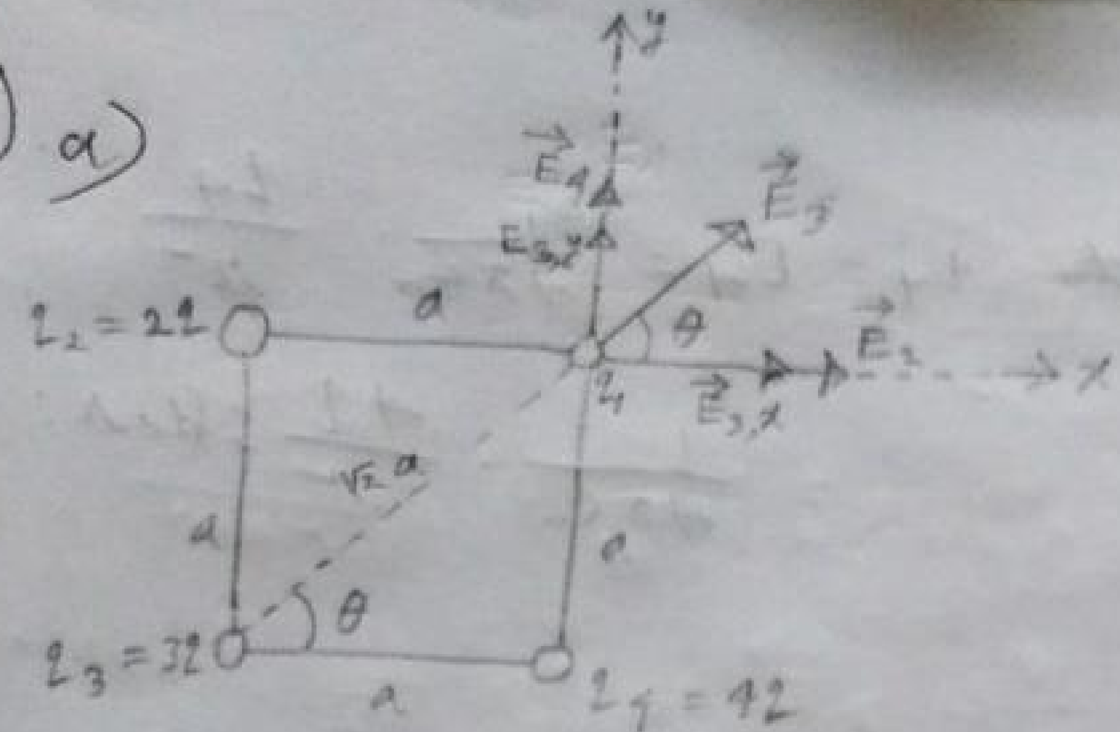
4) a)



suppose, $q_1 = q$, $q_2 = 2q$, $q_3 = 3q$ and $q_4 = 4q$

Electric field on q_1, due to q_2 = $\vec{E}_2 = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_2}{r^2}$

$= \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{a^2}$; (dir: +x)

$\therefore \vec{E}_2 = \hat{i} \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{a^2}$

Electric field on q_1, due to q_3 = $E_3 = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_3}{r^2}$

$= \frac{1}{4\pi\epsilon_0} \cdot \frac{3q}{2a^2}$ [$\because r = \sqrt{2}a$]

~~$= \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{2a^2}$~~

x component of $E_3 = E_{3,x} = E_3 \cos\theta$

$= E_3 \times \frac{a}{\sqrt{2}a}$

$= E_3 \times \frac{1}{\sqrt{2}}$

$= \frac{1}{4\pi\epsilon_0} \cdot \frac{3q}{2a^2} \cdot \frac{1}{\sqrt{2}}$; (dir: +x)

y component of $E_3 = E_{3,y} = E_3 \sin\theta$

$= E_3 \times \frac{a}{\sqrt{2}a}$

$= E_3 \times \frac{1}{\sqrt{2}}$

$= \frac{1}{4\pi\epsilon_0} \cdot \frac{3q}{2a^2} \cdot \frac{1}{\sqrt{2}}$; (dir: +y)

$\therefore \vec{E}_3 = \hat{i} \frac{1}{4\pi\epsilon_0} \cdot \frac{3q}{2a^2} \frac{1}{\sqrt{2}} + \hat{j} \cdot \frac{1}{4\pi\epsilon_0} \cdot \frac{3q}{2a^2} \cdot \frac{1}{\sqrt{2}}$

Electric field on q_1 due to $q_4 = E_4 = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_4}{r^2}$

$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{4q}{a^2} ; (\text{dir}: +y)$$

$$\therefore \vec{E}_4 = \vec{j}\, \frac{1}{4\pi\epsilon_0} \cdot \frac{4q}{a^2}$$

$\therefore$ net electric field on $q_1 = \vec{E}_{1,net} = \vec{E}_2 + \vec{E}_3 + \vec{E}_4$

$$= \left(\hat{i}\, \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{a^2}\right) +$$

$$+\left(\hat{i}\, \frac{1}{4\pi\epsilon_0} \cdot \frac{3q}{2a^2} \cdot \frac{1}{\sqrt{2}}\right) + \vec{j}\, \frac{1}{4\pi\epsilon_0} \cdot \frac{3q}{2a^2} \cdot \frac{1}{\sqrt{2}}\Big)$$

$$+\left(\hat{j}\, \frac{1}{4\pi\epsilon_0} \frac{4q}{a^2}\right)$$

$$= \hat{i}\left[\frac{1}{4\pi\epsilon_0} \cdot \frac{q}{a^2}\left(2 + \frac{3}{2\sqrt{2}}\right)\right] +$$

$$+\hat{j}\left[\frac{1}{4\pi\epsilon_0} \cdot \frac{q}{a^2}\left(\frac{3}{2\sqrt{2}} + 4\right)\right]$$

$$\cancel{= \hat{i}\left[\frac{1}{4\pi\epsilon_0} \cdot \frac{q}{a^2} \cdot \frac{47}{2}\right]}$$

$$\cancel{+\hat{j}\left[\frac{1}{4\pi\epsilon_0} \cdot \frac{q}{a^2}\right.}$$

$$= \hat{i}\left[\frac{1}{4\pi\epsilon_0} \times \frac{q}{a^2} \times 3.06\right]$$

$$= \hat{j}\left[\frac{1}{4\pi\epsilon_0} \times \frac{q}{a^2} \times 5.06\right]$$

$$= \hat{i}\left[9\times10^9 \times \frac{q}{a^2} \times 3.06\right]$$

$$+\hat{j}\ 9\times10^9 \times \frac{q}{a^2} \times 5.06\Big]$$

$$= \hat{i}\times 2.755\times10^{10}\times\frac{q}{a^2} \quad +\hat{j}\times 4.554\times10^{10}\times\frac{q}{a^2}$$

$\therefore$ magnitude of $\vec{E}_{1net} = |\vec{E}_{1net}| = \cancel{\sqrt{(2.755\times10^{10}\times\frac{q}{a^2})^2}}$

$$= \sqrt{\left(2.755\times10^{10}\times\frac{q}{a^2}\right)^2 + \left(4.5546\times10^{10}\times\frac{q}{a^2}\right)^2}$$

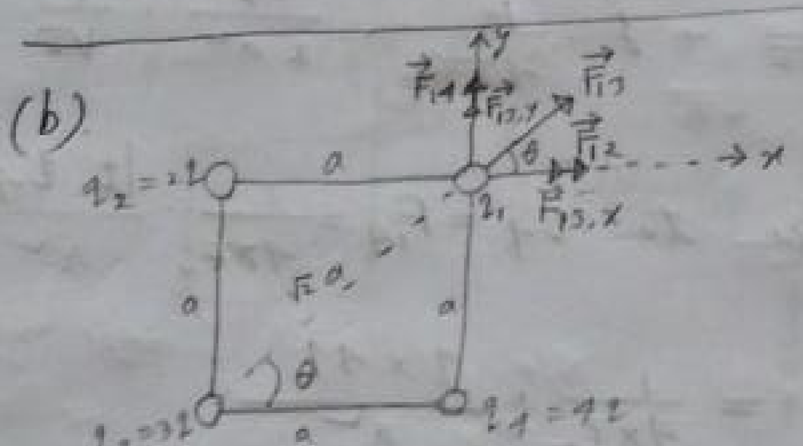
$$= \sqrt{\left[(2.775\times10^{10})^2 + (4.5546\times10^{10})^2\right]\left(\frac{q}{a^2}\right)^2}$$

$$= 5.32\times10^{10}\times\frac{q}{a^2} \text{ N/C}$$

$$\theta = \tan^{-1}\left(\frac{4.5546\times10^{10}\times\frac{q}{a^2}}{2.755\times10^{10}\times\frac{q}{a^2}}\right)$$

$$= \tan^{-1}\left(\frac{4.5546\times10^{10}}{2.755\times10^{10}}\right) = 58.831^\circ$$

(b)



Electrostatic force on q_1, due to $q_2 = F_{12} = \frac{1}{4\pi\epsilon_0}\cdot\frac{|q_1 q_2|}{r^2}$

$$= \frac{1}{4\pi\epsilon_0}\cdot\frac{q\cdot 2q}{a^2}$$

$$= \frac{1}{4\pi\epsilon_0}\cdot\frac{2q^2}{a^2}; \text{(dir: +}$$

$$\vec{F}_{12} = \hat{i}\,\frac{1}{4\pi\epsilon_0}\cdot\frac{2q^2}{a^2}$$

Electrostatic force on q_1, due to $q_3 = F_{13} = \frac{1}{4\pi\epsilon_0}\cdot\frac{|q_1 q_3|}{r^2}$

$$= \frac{1}{4\pi\epsilon_0}\cdot\frac{q\cdot 3q}{(\sqrt{2}a)^2}$$