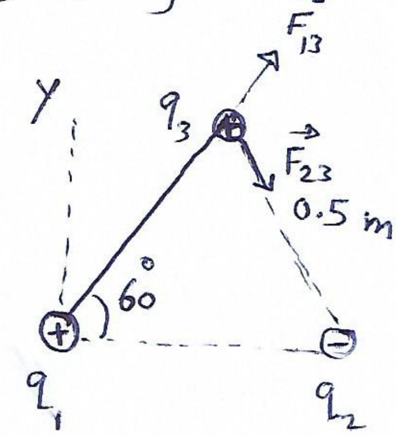
(1) Q23.4

$$|\vec{F}_{12}| = |F_{21}| = K\frac{q_1 q_2}{r^2} = \frac{9\times10^{9}\times(1.6\times10^{-19})^2}{(2\times10^{-15})^2}$$

$$= 57.5\,N \quad \text{very strong}$$

(2) Q23.7 :

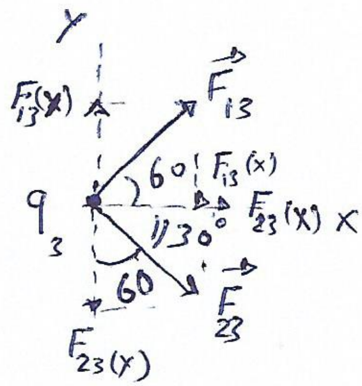


$$\vec{F}_{13} = \frac{K_e q_1 q_3}{r_{13}^2} = \frac{9\times10^{9}\times2\times10^{-6}\times7\times10^{-6}}{(0.5)^2}$$

$$= 0.503\ N$$

$$\vec{F}_{23} = \frac{K_e q_2 q_3}{r_{23}^2} = \frac{9\times10^{9}\times4\times10^{-6}\times7\times10^{-6}}{(0.5)^2}$$

$$= 1.01\ N$$



$$\vec{F}_x = \vec{F}_{13}(x) + \vec{F}_{23}(x)$$

$$= F_{13}\cos 60 + F_{23}\cos 30$$

$$= 0.503\times\frac{1}{2} + 1.01\times0.866$$

$$= 0.755\,N$$

$$\vec{F}_y = \vec{F}_{13}(y) + \vec{F}_{23}(y)$$

$$= F_{13}\sin 60 - F_{23}\sin 30$$

$$= 0.503\times0.866 - 1.01\times\frac{1}{2}$$

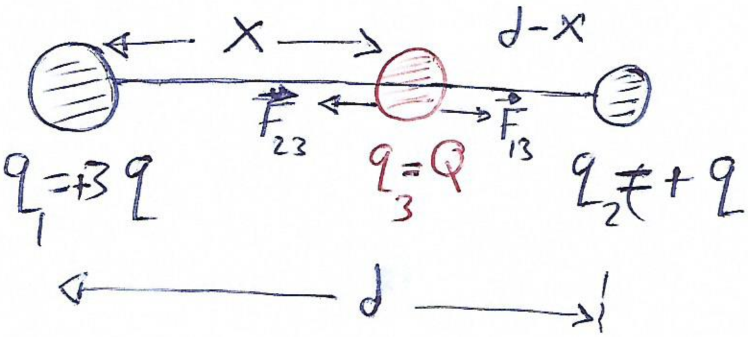
$$= -0.436\ N$$

$$\Rightarrow \vec{F}_3 = F_x\hat{i} + F_y\hat{j} = 0.755\,\hat{i} - 0.436\,\hat{j} \quad (N)$$

$$|\vec{F}_3| = \sqrt{(0.755)^2 + (0.436)^2} = 0.872\ N$$

$$\phi = \tan^{-1}\left(\frac{F_y}{\ldots}\right) = \tan^{-1}\left(\frac{-0.436}{\ldots}\right) = -30° \text{ with x}$$

(3) Q 23.10



At equilibrium

$$|\vec{F}_{23}| = |\vec{F}_{13}|$$

$$\frac{\cancel{k} q_2 q_3}{r_{23}^2} = \frac{\cancel{k} q_1 q_3}{r_{13}^2}$$

$$\frac{\cancel{qQ}}{(d-x)^2} = \frac{3\cancel{qQ}}{x^2}$$

$$\frac{1}{(d-x)^2} = \frac{3}{x^2}$$

$$\sqrt{\frac{1}{(d-x)^2}} = \sqrt{\frac{3}{x^2}}$$

$$\Rightarrow \frac{1}{d-x} = \frac{\sqrt{3}}{x}$$

$$\Rightarrow x = \sqrt{3}(d-x) = \sqrt{3}\,d - \sqrt{3}\,x$$

$$\Rightarrow x + \sqrt{3}\,x = \sqrt{3}\,d \quad \Rightarrow$$

(4) Q 23.14

$q = 24\ \mu C$

$\vec{E} = 610\ N/C$

$\Rightarrow qE = mg$

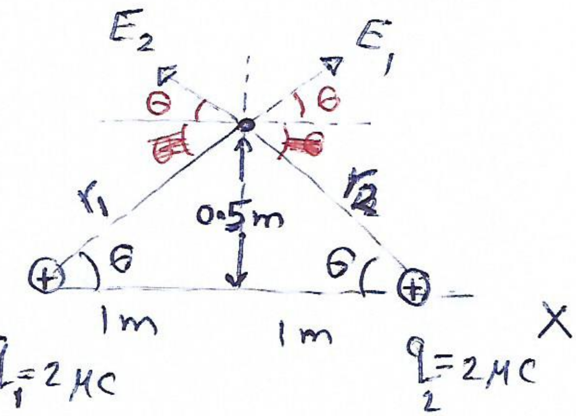
$$m = \frac{qE}{g} = \frac{24 \times 10^{-6} \times 610}{9.8} \cong 1.5 \times 10^{-3}\ Kg$$

$\simeq 1.5\ gm$

(5) Q 23.20

(a)

$r_1 = r_2 = \sqrt{(1)^2 + (0.5)^2} = 1.12\ m$



$$E_1 = E_2 = \frac{K q_1}{r_1^2} = \frac{K q_2}{r_2^2}$$

because $r_1 = r_2$, $q_1 = q_2$

$$\Rightarrow E_1 = E_2 = \frac{9 \times 10^9 \times 2 \times 10^{-6}}{(1.12)^2} = 14.4 \times 10^3\ N/C$$

Field	X-Comp.	Y-Comp.
E_1	$E_1 \cos\theta$	$E_1 \sin\theta$
E_2	$-E_2 \cos\theta$	$E_2 \sin\theta$
Resultant	0	$2E_1 \sin\theta$
	because $E_1 = E_2$	$E_1 = E_2$

Q23.20 (b)

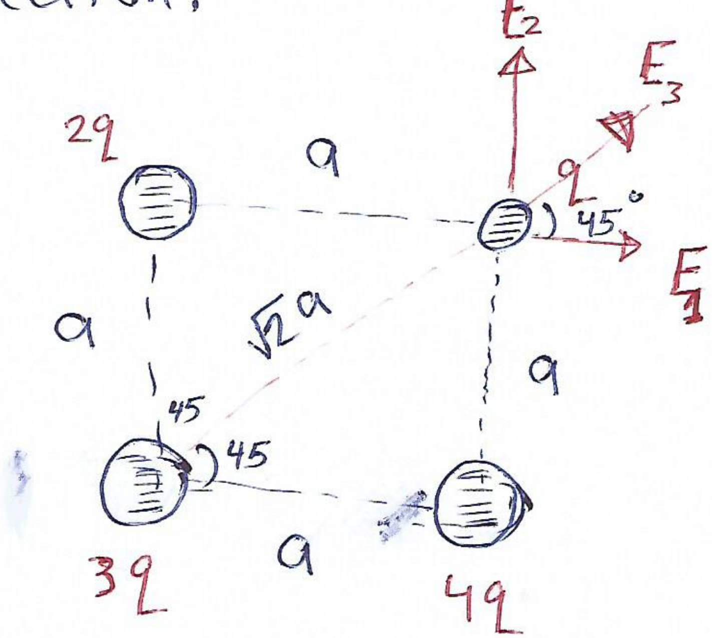
$$F = qE$$

$$= -3\times10^{-6} \times 1.29\times10^{4}$$

$$= -3.86\times10^{-2}\,N$$

in $-y$ direction.

(6) Q23.21



(a)

$$E_1 = \frac{Kq_1}{r_1^2}, \quad r_1 = a$$

$q_1 = 2q$

$$\Rightarrow E_1 = \frac{2Kq}{a^2}$$

$$E_2 = \frac{Kq_2}{r_2^2}, \quad r_2 = a$$

$$q_2 = 4q \Rightarrow E_2 = \frac{4Kq}{a^2}$$

$$E_3 = \frac{Kq_3}{r_3^2}, \quad r_3 = \sqrt{2}\,a$$

$$q_3 = 3q \Rightarrow E_3 = \frac{3Kq}{2a^2}$$

E	X-comp	Y-comp
E_1	$E_{1x} = E_1$	$E_{1y} = 0$
E_2	$E_{2x} = 0$	$E_{2y} = E_2$
E_3	$E_3 \cos\theta$	$E_3 \sin\theta$
$\vec{E}_{net}$	E_x	E_y

E_3 has tw components

$$E_{3x} = E_3 \cos\theta$$

$$E_{3y} = E_3 \sin\theta$$

$$E_x = E_1 + E_3\cos\theta$$

$$= \frac{2Kq}{a^2} + \frac{3Kq}{2a^2} \times \left(\frac{\cancel{a}}{\sqrt{2}\,\cancel{a}}\right)$$

$$= \frac{4\sqrt{2}\,Kq + 3Kq}{2\sqrt{2}\,a^2} = 3.06\,Kq$$

$$\Rightarrow \vec{E}_{net} = 3.06 \frac{Kq}{a^2}\hat{i} + 5.06\frac{Kq}{a^2}\hat{j}$$

Magnitude $\Rightarrow \sqrt{\left(\frac{3.06\,Kq}{a^2}\right)^2 + \left(\frac{5.06\,Kq}{a^2}\right)^2}$

$$= 5.91\frac{Kq}{a^2}$$

angle $\phi = \tan^{-1}\left(\frac{E_y}{E_x}\right) = \tan^{-1}\left(\frac{5.06\,\cancel{Kq/a^2}}{3.06\,\cancel{Kq/a^2}}\right)$

$$\phi = \tan^{-1}\left(\frac{5.06}{3.06}\right) = 58.8^\circ$$

(b) $\vec{F} = q\vec{E} = 5.91\frac{Kq^2}{a^2}$

$$\phi = 58.8^\circ$$

Q 23.42 $\quad F = qE \Rightarrow ma$

for electron $\Rightarrow \vec{a} = \frac{q\vec{E}}{m} = \frac{-1.6\times10^{-19}\times520}{9.1\times10^{-31}} = -9.14\times10^{+13}\ m/s^2$

$\Rightarrow v_f = v_0 + at = 0 - 9.14\times10^{13}\times48\times10^{-9}$

$= -4.39\times10^{6}\ m/s$

opposite to the field direction

for proton $\vec{a} = \frac{q\vec{E}}{m} = \frac{1.6\times10^{-19}\times520}{1.67\times10^{-27}} = 4.98\times10^{+10}\ m/s^2$

$\Rightarrow v_f = v_0 + at \ldots$

Q 23.45 to stop the electrons

the Electric field needs to do work on the electrons

$$W = \Delta K = \frac{1}{2} m_e (v_f^2 - v_i^2)$$

$$\vec{F} \cdot \vec{d} = \frac{1}{2} m_e (0 - v_i^2)$$

$$qEd = -\frac{1}{2} m_e v_i^2$$

$q = -e$ for electrons

$$\cancel{-} eEd = \cancel{-} \frac{1}{2} m_e v_i^2$$

$$\Rightarrow E = \frac{\frac{1}{2} m_e v_i^2}{ed} = \frac{K_i}{ed}$$

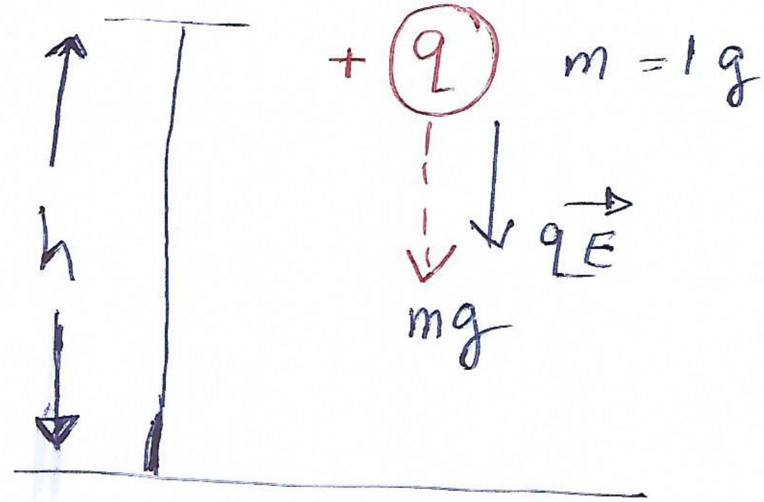
the field direction will be in the direction of electron motion.

Q 23.46

$m = 1 \times 10^{-3}$ Kg.

$v_i = 0$

$v_f = 21$ m/s



in order to determine the direction of the field, ~~we need~~ we need to know about the acceleration:

$$v_f^2 = v_i^2 + 2 a_y \Delta h$$

$$(21)^2 = 0 + 2 a_y \times 5$$

$$\Rightarrow a_y = 44.1 \text{ m/s}^2$$

$a_y = g + a$ (from the electric field)

therefore the electric field must have downward direction.

$$a_{\text{electric field}} = 44.1 - 10 = 34.1 \text{ m/s}^2$$