Lec 1

chpt 21

#25 $q = 1.6 \times 10^{-19}$

$N = \frac{1 \times 10^{-7}}{q} = 6.25 \times 10^{-14}$

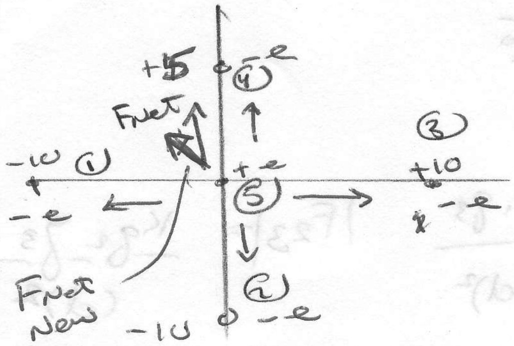
*27. $F = \frac{K q_1 q_2}{d^2}$

$3.7 \times 10^{-9} = \frac{K q^2}{(5 \times 10^{-10})^2}$, $K = \frac{1}{4\pi\epsilon_0}$

$q = 3.2 \times 10^{-19}$

and $\# = \frac{q}{e} = 2$ electrons missing from each

29.



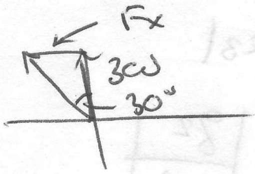
$|F_{54}| = \frac{Ke^2}{(0.05)^2} = 400$ $|F_{51}| = \frac{Ke^2}{(0.1)^2} = |F_{53}|$

$= 100$ N

$|F_{52}| = \frac{Ke^2}{(0.1)^2} = 100$

$F_{Net} = 300$ N

FNet New



$\tan 30° = \frac{F_x}{300}$

$F_x = 173.2$ N

so with 100 N of $|F_{53}|$ to right, need

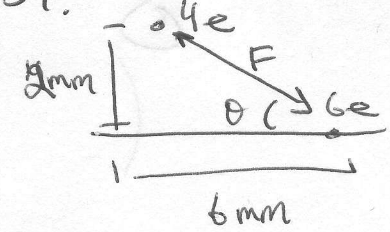
$F_x + |F_{53}| = 273.2$ N to left

$\therefore$ $273.2 = \frac{Ke^2}{d^2}$

$|d| = 6$ cm (i.e. move 1 to -6 cm)

b) to restore previous symmetry, make q_3 at $+6$ cm

39.



$$F = \frac{k q_1 q_2}{r^2} = \cancel{8.69 \times 10^{-4}\ N}$$

$$= 1.4 \times 10^{-22}$$

$$\theta = \tan^{-1}\left(\frac{2}{6}\right) = 18.4^\circ$$

$r = 0.0063$ m

$$\therefore F_x = F\cos\theta$$

$$= \cancel{8.24 \times 10^{-4}\ N} \; 1.32 \times 10^{-22}\ N$$

Lec2

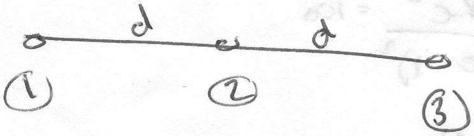
1. $F = \dfrac{k q_1 q_2}{r^2}$ 2C

$= \dfrac{k(Q-q)(q)}{r^2}$ and so $\dfrac{dF}{dq} = \left(\dfrac{k}{r^2}\right)(Q-2q) = 0$

$$q = \frac{Q}{2}$$

5. $F = \dfrac{k q_1 q_2}{r^2} = 2.8\ N$

7.



$|F_{13}| = \dfrac{k q_1 q_3}{(2d)^2}$ $|F_{23}| = \dfrac{k q_2 q_3}{(d)^2}$

and $|F_{13}| = |F_{23}|$

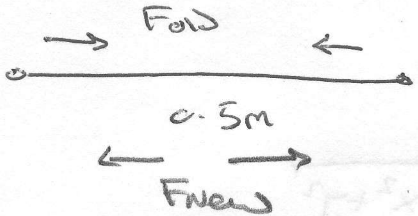
$\therefore \left|\dfrac{q_1}{(2d)^2}\right| = \left|\dfrac{q_2}{d^2}\right|$

$\left|\dfrac{q_1}{q_2}\right| = 4$ and sign is -ve since forces must cancel.

F = 0.108 N

Chap 21

9.



$F_{old} = 0.108N = \frac{K q_1^o q_2^o}{r^2}$

$F_{New} = 0.036N = \frac{K q_1^N q_2^N}{r^2}$

$$\frac{F_{old}}{F_{New}} = \frac{q_1^o q_2^o}{q_1^N q_2^N} = 3$$

after wire, $q_1^N = q_2^N$ so $F_{New} = 0.036 = \frac{K(q^N)^2}{r^2}$

$q^N = 1 \times 10^{-6}$ C

so $|q_1^o q_2^o| = 3 \times 10^{-12}$

and total charge is $2q^N = 2 \times 10^{-6} = q_1^o + q_2^o$

Initially, spheres attract so have opposite signs

so from $F_{old} = 0.108 = \frac{k q_1^0 q_2^0}{r^2}$, make one charge $+ve$ and other $-ve$

$\underbrace{}_{= q_1^0}$

$\therefore 0.108 = k(\overbrace{2\times10^{-6}\} - q_2^0}^{})(-q_2^0)$

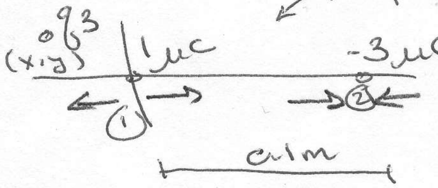
$3\times10^{-12} = -2\times10^{-6} q_2^0 + (q_2^0)^2$

$q_2^0 = 3\mu C, -1\mu C$

and $q_1^0 = -1\mu C, +3\mu C$ (from $|q_1^0 q_2^0| = 3\times10^{-12}$)

Chp 21

13.



not possible here since $\vec{F}_{net} \neq 0$

$\vec{F} = q\vec{E}$ so make $\vec{E} = 0$ to have no net force

$\vec{E}_1 = \frac{k(1\mu C)}{r_1^2}\hat{r}_1 \qquad \vec{E}_2 = \frac{-k(3\mu C)}{r_2^2}\hat{r}_2$

and want $\vec{E}_1 + \vec{E}_2 = 0$

$k\left(\frac{1}{r_1^2} - \frac{3}{r_2^2}\right)(1\times10^{-6}) = 0$

so $\left(\frac{1}{r_1^2} - \frac{3}{r_2^2}\right) = 0$ where $r_1 = \sqrt{x^2+y^2}$

$r_2 = \sqrt{(x-0.1)^2 + y^2}$

$3x^2 + 3y^2 = (x-0.1)^2 + y^2$

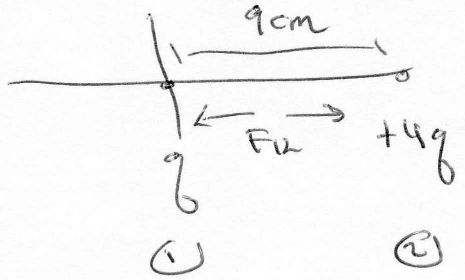
$2x^2 + 2y^2 + 0.2x - 0.01 = 0$

let $y = 0 \rightarrow x = \frac{-0.2 \pm \sqrt{(0.2)^2 + 4(2)(0.01)}}{\cancel{8}4}$

$= -13.6 \text{ cm}$

Chap 21

19.



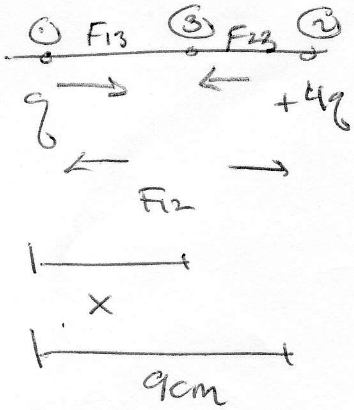
when add q_3, nothing should move.

∴ must be on x-axis since otherwise will have force in $\hat{j}$ direction

↳ $\boxed{y=0}$

- ~~cant~~ cannot be +ve charge since all particles will repel each other

- −ve charge only in middle between ① and ②



$$F_{12} = \frac{4kq^2}{(0.09)^2}$$

and need F_{13}, F_{23} to balance out F_{12}

$$\therefore F_{13} = \frac{kq(-q_3)}{x^2} = F_{12}$$

$$F_{23} = \frac{-4kqq_3}{(0.09-x)^2} = F_{12}$$

So get $\frac{4kq^2}{(0.09)^2} = \frac{-kqq_3}{x^2}$ and $\frac{-4kqq_3}{(0.09-x)^2} = \frac{4kq^2}{(0.09)^2}$

$$\frac{-q_3}{q} = \frac{4x^2}{(0.09)^2} \qquad \frac{-q_3}{q} = \frac{(0.09-x)^2}{(0.09)^2}$$

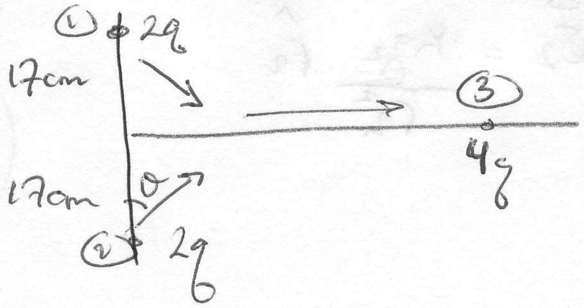
$$\therefore \frac{4x^2}{(0.09)^2} = \frac{(0.09-x)^2}{(0.09)^2}$$

$$4x^2 = 0.0081 - 0.18x + x^2$$

$$\underline{x = 3cm}$$

and $\frac{q_3}{q} = \frac{-4x^2}{(0.09)^2} = \underline{-0.44}$

23.



$$\boxed{\text{min @ } x=0 \ \therefore\ \downarrow\uparrow\ F_{net}=0 \quad (a) \quad (c) \quad 3}$$

$|F_{13}| = \frac{K(2q)(4q)}{r_1^2}$ $\quad |F_{23}| = \frac{(K)(8q^2)}{r_2^2}$ $\quad r_1 = r_2 = \sqrt{x^2+(0.17)^2} = r$

$F_{net} = F_{13} + F_{23}$

$= (8q^2K)\left(\frac{2}{r^2}\right) \rightarrow \overset{16Kq^2}{(-1)}\left(\frac{1}{x^2+(0.17)^2}\right)$ $\quad [x^2+(0.17)^2]^{-1}$

$\frac{\partial F_{net}}{\partial x} = \frac{(16Kq^2)(-1)(2x)}{(x^2+(0.17)^2)^2}$ and $x=0$ gives min/max as expected.

so $\underline{\underline{F_x^{net}}} \rightarrow \theta = \tan^{-1}\left(\frac{x}{0.17}\right)$

$F_{13}^x = K8q^2 \frac{\sin\theta}{r^2}$ $\quad F_{23}^x = 8q^2K \frac{\sin\theta}{r^2}$

$\therefore F_{net}^x = 16Kq^2 \frac{\sin(\tan^{-1}(\frac{x}{0.17}))}{x^2+(0.17)^2}$

$\boxed{\rightarrow \text{plot and get max @ (b) } x = 0.12\text{ m} \quad \text{d) } F_{max} = 4.9\times10^{-26}\text{ N}}$

Lec 3

chp 22

2. $F = qE$

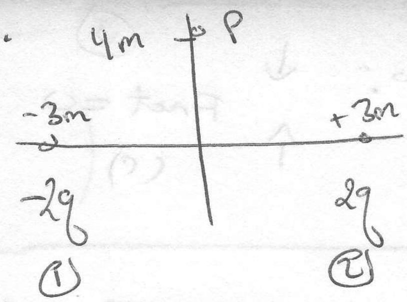
a) $F = (1.6\times10^{-19})(\cancel{}\,40) = 6.4\times10^{-18}$

b) Density $\downarrow 2$ so $E = 20$ N/C

5. $E = \frac{Kq}{r^2}$

$2 = \frac{Kq}{(0.5)^2} \rightarrow q = \frac{1}{2K} = \frac{1.1\times10^{-10}}{2} = 0.55\times10^{-10}$ C

9.



$\vec{E}_1 = \frac{Kq_1}{r_1^2}\hat{r}_1 \qquad \vec{E}_2 = \frac{Kq_2}{r_2^2}\hat{r}_2$

$|r_1| = |r_2| = 5m = \sqrt{3^2+4^2}$

$\hat{r}_1 = \frac{3\hat{x}+4\hat{y}}{\sqrt{5}} \qquad \hat{r}_2 = \frac{-3\hat{x}+4\hat{y}}{\sqrt{5}}$

$\therefore \vec{E}_1 = \left(\frac{-K(2q)}{(\sqrt{5})^2}\right)\left(\frac{3\hat{x}+4\hat{y}}{\sqrt{5}}\right) \qquad \vec{E}_2 = \left(\frac{+K(2q)}{(\sqrt{5})^2}\right)\left(\frac{-3\hat{x}+4\hat{y}}{\sqrt{5}}\right)$

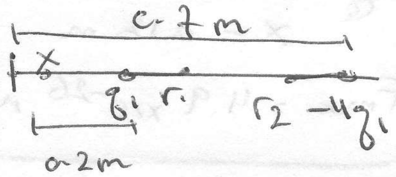
$= \frac{-6qK\hat{x} - 8qK\hat{y}}{5\sqrt{5}} \qquad = \frac{-6qK\hat{x} + 8qK\hat{y}}{5\sqrt{5}}$

and $\vec{E}_{Total} = \vec{E}_1 + \vec{E}_2$

$= \frac{-12qK\hat{x}}{5\sqrt{5}}$ (i.e to the left)

$(q = 1.6\times10^{-19})$

11.



$|\vec{E}_1| = \frac{Kq}{|r_1|^2} = \frac{Kq_1}{r_1^{2}} \qquad |\vec{E}_2| = \frac{4Kq_1}{(r_2)^2}$

$|E_{Total}| = |E_1| + |E_2|$

$= Kq_1\left(\frac{1}{(r_1)^2} - \frac{4}{(r_2)^2}\right)$

so want $\left(\frac{1}{r_1}\right)^2 = \left(\frac{4}{r_2}\right)^2$

$r_1 = \frac{r_2}{2}$ actually do $|r_1| = x - 0.2$

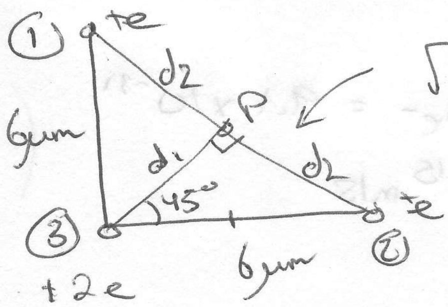
$|r_2| = x - 0.7$

$2(x - 0.2) = x - 0.7$

$x = -0.3 \Longrightarrow$ so at $-0.3m$

~~$x = 0.033 = 3.3cm$~~

15.



$\sqrt{36+36} \cong 8.5\mu m$ and $d_2 = 4.2\frac{?}{?}\mu m$

P is at $(3,3)_{\mu m}$

$\therefore d_1 = \sqrt{3^2+3^2} = 4.2\,\mu m = d_2 = d$

$$\vec{E}_1 = \left(\frac{Ke}{d_2^{\,2}}\right)\left(\frac{3\mu m\,\hat{x} - 3\mu m\,\hat{j}}{4.2\frac{?}{?}\mu m}\right) =$$

$$\vec{E}_2 = \left(\frac{Ke}{d^2}\right)\left(\frac{-3\mu m\,\hat{x} + 3\mu m\,\hat{j}}{d}\right)$$

$$\vec{E}_3 = \frac{2Ke}{d^2}\left(\frac{3\mu m\,\hat{x} + 3\mu m\,\hat{j}}{d}\right)$$

$$\vec{E}_{Total} = \cancel{\frac{Ke}{d}} = \vec{E}_3 = \cancel{6}\frac{Ke}{d^3}(6\mu m\,\hat{x} + 6\mu m\,\hat{j})$$

and mag is $|\vec{E}_3| = \dfrac{2Ke}{d^2} = \cancel{6.0\times10^{-4}}\ N/C = 163\ N/C$

41. $\circ\downarrow\ F = q\vec{E}$

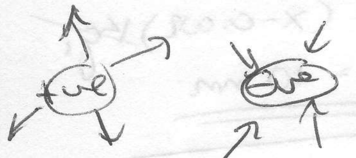
a) $3\times10^{-6} = (2\times10^{-9})|\vec{E}|$

$|\vec{E}| = 1500\ N/C$

b) $|F_{el}| = (1.6\times10^{-19})|\vec{E}|$

$= 2.4\times10^{-16}\ N$

and acts upwards since field drove -ve charge down.



c) $F_g = \dfrac{G\,m_1 m_2\,\hat{r}}{r^2}$

$= 1.6\times10^{-26}\ N$

$m_{proton} = 1.67\times10^{-27}\ Kg$ (page 571)

$G = 6.67\times10^{-11}\ Nm^2/Kg^2$

$m_{earth} = 5.9\times10^{24}\ Kg$

$r_{earth} = 6353\,km \cong 6.4\times10^6\ m$

d) $\dfrac{F_{el}}{F_g} = 1.5\times10^{10}$

43. $F = qE = (q)(2 \times 10^{4})$

$= 3.2 \times 10^{-15}\ N = ma, \quad m_{e^-} = 9.1 \times 10^{-31}$

$a = 3.5 \times 10^{15}\ m/s$

44. $m_\alpha = 6.64 \times 10^{-27}\ kg \quad q_\alpha = +2e$

$F_g = \frac{G m_1 m_2}{r^2} = 6.4 \times 10^{-26}\ N$

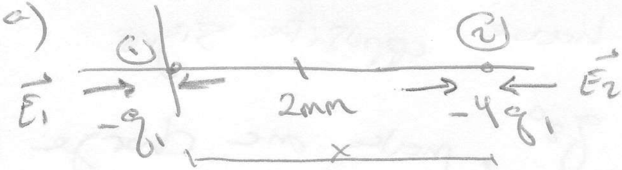
make $|F_{el}| = |F_g|$

$|qE| = 6.4 \times 10^{-26}$

$|E| = 2 \times 10^{-7}\ N/C$

and since $\vec{F_g}$ points down, $\vec{F_{el}}$ must point up.

77. a)



$|E_1| = \frac{kq_1}{r^2}$ $|E_2| = \frac{4kq_1}{(x-0.002)^2}$

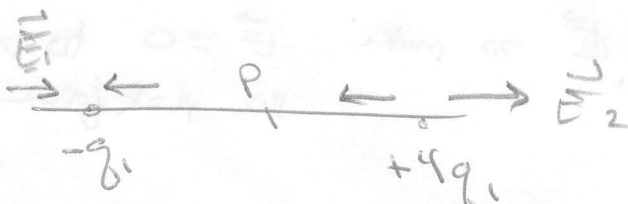
and want $|E_1| = |E_2|$

$$\frac{4}{(x-0.002)^2} = \frac{1}{r^2}$$

$$x - 0.002 = 2r, \quad r = 2\times10^{-3}$$

$$\underline{\underline{x = 6\times10^{-3}\ \text{m}}}$$

b)



so net direction is $\underline{\underline{-\hat{x}}}$