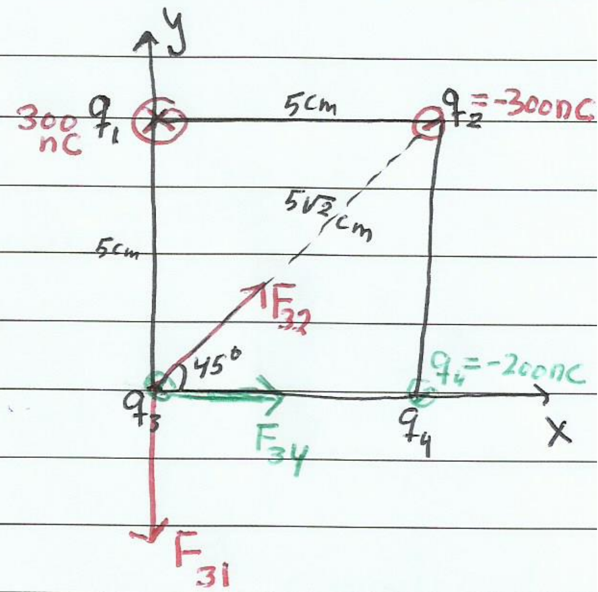
Chapter-21 Lecture Problems

(21-3) $q_1 = -q_2 = 300\,nC$

$q_3 = -q_4 = 200\,nC$

$a = 5\,cm$

$\vec{F_3}$?



All vectors (Forces) must Begin from q_3

$$F_{31} = \frac{9\times10^{9} \times 200\times10^{-9} \times 300\times10^{-9}}{(5\times10^{-2})^2}$$

$\vec{F}_{31} = 0.216\,N$ in $(-y)$ or $-\hat{j}$

$$F_{32} = \frac{9\times10^{9} \times 200\times10^{-9} \times 300\times10^{-9}}{(5\sqrt{2}\times10^{-2})^2}$$

$\vec{F}_{32} = 0.108\,N$ at $45°$ with $+x$

$$F_{34} = \frac{9\times10^{9} \times 200\times10^{-9} \times 200\times10^{-9}}{(5\times10^{-2})^2}$$

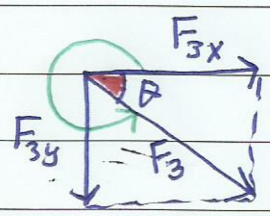
$\vec{F}_{34} = 0.144\,N$ in $+x$

$\vec{F_3} = \vec{F}_{31} + \vec{F}_{32} + \vec{F}_{34}$

$(F_3)_x = 0.144 + F_{32}\cos 45 = 0.144 + 0.108(0.707)$
$= 0.22\,N$

$(F_3)_y = -F_{31} + F_{32}\sin 45 = -0.216 + 0.108\sin 45$
$= -0.14\,N$

$F_3 = \sqrt{F_{3x}^2 + F_{3y}^2} = \sqrt{(0.22)^2 + (-0.14)^2}$
$= 0.26\,N$



$\theta = \tan^{-1}\left(\frac{F_{3y}}{F_{3x}}\right) = \tan^{-1}\left(\frac{-0.14}{0.22}\right)$

$\theta = -32.5°$

① $\vec{F_3} = 0.22\hat{i} - 0.14\hat{j}\ N$ 3 methods to describe $\vec{F_3}$

② $\vec{F_3} = 0.26\,N$ at $32.5°$ with $+x$ clockwise

③ $\vec{F_3} = 0.26\,N$ at $327.5°$ with $+x$ Counterclockwise

(21-6)

q_1 at $x_1 = -a$

q_2 at $x_2 = +a$

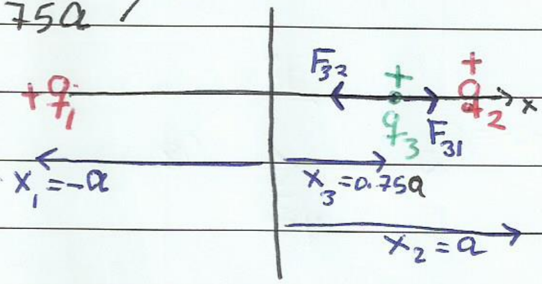
$\vec{F_3} = 0$ on $q_3 = +Q$

a) Find $\frac{q_1}{q_2}$? when $\underset{=Q}{q_3}$ at $x_3 = +0.75a$ ↗ For $\vec{F_3} = 0$

both q_1 & q_2 must be possitive

or

both q_1 & q_2 must be negative



$\Rightarrow \frac{q_1}{q} = +?$

$\vec{F_3} = \vec{F_{31}} + \vec{F_{32}}$, $\vec{F_3} = 0 \Rightarrow \vec{F_{31}} = -\vec{F_{32}}$ opposite and equal

$0 = \frac{k q_1 Q}{(a+0.75a)^2}\hat{i} + \frac{k q_2 Q}{(0.25a)^2}(-\hat{i}) \Rightarrow \frac{k q_1 Q}{(1.75a)^2} = \frac{k q_2 Q}{(0.25a)^2}$

$\frac{q_1}{(1.75)^2} = \frac{q_2}{(0.25)^2} \Rightarrow \frac{q_1}{q_2} = \left(\frac{1.75}{0.25}\right)^2 = (7)^2$

$\frac{q_1}{q_2} = +49$

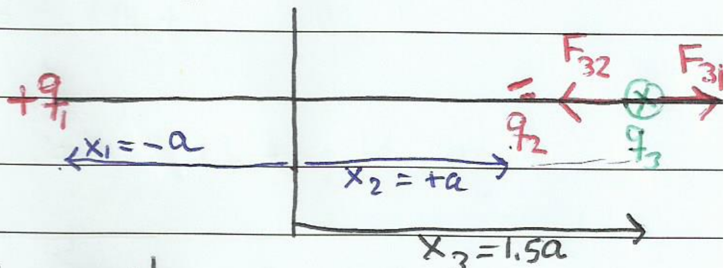
b) Find $\frac{q_1}{q_2} = ?$ When $q_3 = +Q$ at $x_3 = 1.5a$

For $\vec{F_3} = 0$

$\vec{F_3} = \vec{F_{31}} + \vec{F_{32}}$

For $\vec{F_3} = 0$

$\vec{F_{31}} + \vec{F_{32}} = 0 \Rightarrow$



$\vec{F_{31}} = -\vec{F_{32}}$ must be equal + opposite

let q_1 be positive, then q_2 must be negativen $\Rightarrow \frac{q_1}{q_2} = -?$

$\frac{k q_1 Q}{(2.5a)^2} = \frac{k q_2 Q}{(0.5a)^2} \Rightarrow \frac{q_1}{(2.5)^2} = \frac{q_2}{(0.5)^2}$

$\frac{q_1}{q_2} = \left(\frac{2.5}{0.5}\right)^2 = (5)^2 = 25 \Rightarrow$

$\frac{q_1}{q_2} = -25$

(21-31)

$q_1 = q_2 = +4e$

$q_3 = +8e$

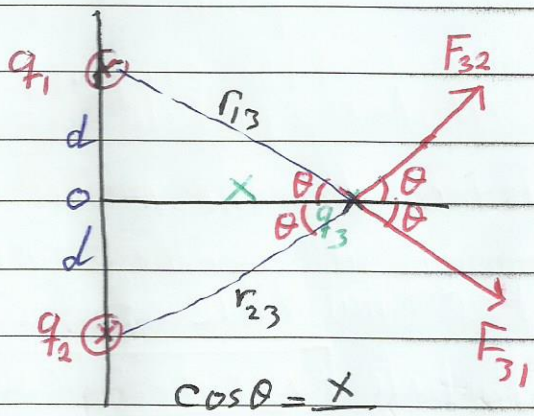
$d = 17.0\,cm$

$x\,(0 \longrightarrow 5m)$

Find x? for $\vec{F}_3$ is max

Find x? For $\vec{F}_3$ is min.

Find $(F_3)_{max}$? $(F_3)_{min}$?



$\cos\theta = \dfrac{x}{r_{13}}$

$\cos\theta = \dfrac{x}{\sqrt{d^2+x^2}}$

$r_{13} = r_{23} = \sqrt{d^2+x^2}$

$F_{31} = F_{32} = \dfrac{k\,q_1 q_3}{(r_{13})^2} = \dfrac{k(4e)(8e)}{\left[\sqrt{d^2+x^2}\right]^2} = \dfrac{32ke^2}{d^2+x^2}$, the direction for each Force on the figure.

$\vec{F}_3 = \vec{F}_{31} + \vec{F}_{32}$

$(F_3)_x = \dfrac{32ke^2}{d^2+x^2}\cos\theta + \dfrac{32ke^2}{d^2+x^2}\cos\theta = 2\left(\dfrac{32ke^2}{d^2+x^2}\right)\left(\dfrac{x}{\sqrt{d^2+x^2}}\right)$

$(F_3)_x = 64ke^2\left(\dfrac{x}{(d^2+x^2)^{3/2}}\right)$

$(F_3)_{min} = 0$ at $x = 0$

$(F_3)_y = \overset{-}{F}_{31}\sin\theta + \overset{+}{F}_{32}\sin\theta = 0$

$F_3 = 64ke^2\,\dfrac{x}{(d^2+x^2)^{3/2}}$

to find F_{max} + F_{min} do $\dfrac{dF_3}{dx}$ must equal zero

$\dfrac{dF_3}{dx} = 64ke^2\,\dfrac{d}{dx}\left[x(d^2+x^2)^{-3/2}\right]$

$0 = 64ke^2\left[(1)(d^2+x^2)^{-3/2} + x\left(-\tfrac{3}{2}\right)(2x)(d^2+x^2)^{-5/2}\right]$

$\dfrac{3x^2}{(d^2+x^2)^{5/2}} = \dfrac{1}{(d^2+x^2)^{3/2}} \Longrightarrow 3x^2 = \dfrac{(d^2+x^2)^{5/2}}{(d^2+x^2)^{3/2}}$

$3x^2 = d^2 + x^2 \Rightarrow 2x^2 = d^2 \Rightarrow x = \dfrac{d}{\sqrt{2}}$ for $(F_3)_{max}$

$(F_3)_{max} = 64ke^2\left(\dfrac{d/\sqrt{2}}{\left[d^2 + d^2/2\right]^{3/2}}\right)$

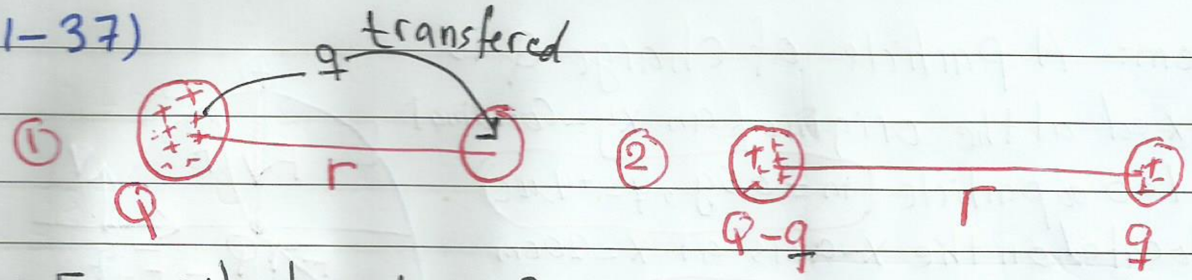
$= 64ke^2\left[\dfrac{d}{\sqrt{2}\left[1.5d^2\right]^{3/2}}\right]$

$k = 9\times10^9$

$d = 17\times10^{-2}\,m$

$e = 1.6\times10^{-19}\,C$

(21-37)



a) For what value $\frac{q}{Q}$? will maximaize theforce between the 2spheres

$$F = \frac{k q_1 q_2}{r^2} = k\,\frac{q(Q-q)}{r^2}$$

$\frac{dF}{dq}$ must be zero for F to be maximum

$$\frac{dF}{dq} = \frac{k}{r^2}\frac{d}{dq}(Qq - q^2) = \frac{k}{r^2}(Q-2q)$$

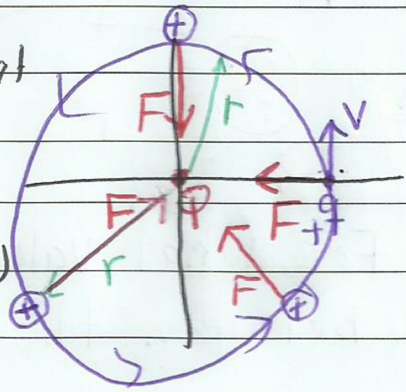
$$0 = \frac{k}{r^2}(Q-2q) \Longrightarrow Q - 2q = 0 \Rightarrow q = \frac{1}{2}Q$$

$$\boxed{\frac{q}{Q} = \frac{1}{2}} \text{ for } F_{max}$$

$$F_{max} = k\left(\frac{q_1 q_2}{r^2}\right) = \frac{k}{r^2}\left[\left(\frac{1}{2}Q\right)\left(\frac{1}{2}Q\right)\right] = \frac{kQ^2}{4r^2}$$

b) do this part.

Problem:- A particle of charge Q is fixed at the origin of an xy-Coordinat



At $t=0$ a particle $(m=0.5g, q=+4\mu C)$ is located on the x-axis at $x=20cm$ moving with speed of $50 m/s$ in the $(+y)$

For what value of Q will the moving Particle execute circular motion

[Neglect gravitational Force on the Particle

For the Particle to move circular motion Force on the Particle must be toward the center $\Longrightarrow$ Q must be negative

$$F_q = k\frac{qQ}{r^2} \quad , r = 20cm \quad , q = +4\times10^{-6}$$

$$\frac{mv^2}{r} = \frac{kqQ}{r^2} \Longrightarrow \quad m = 0.5\times10^{-3} kg$$

$$Q = \frac{mv^2 r}{kq}$$

$$Q = \frac{(0.5\times10^{-3})(50)^2(0.2)}{(9\times10^{9})(4\times10^{-6})} = 6.94\times10^{-6} C$$
$$= 6.94 \mu C$$

$$Q = -6.94 \mu C$$