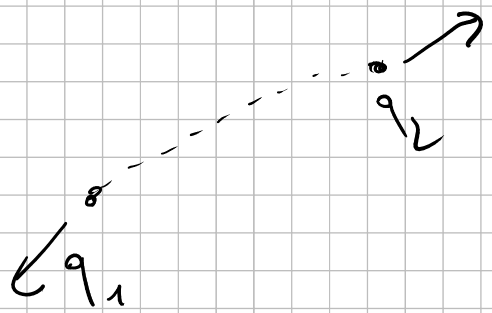
davide.campi@unimib.it

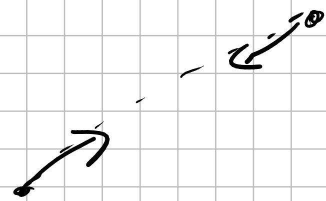
$$\vec{F}_{12} = k_e \cdot \frac{q_1 \cdot q_2}{r_{12}} \cdot \hat{r}_{12}$$

$$k_e = \frac{1}{4\pi\varepsilon_0} = 8{,}987 \cdot 10^9 \frac{Nm^2}{C^2} \approx 9 \cdot 10^9 \frac{Nm^2}{C^2}$$



$q_1 > 0$, $q_2 > 0$

$q_1 < 0$, $q_2 < 0$



$q_1 > 0$, $q_2 < 0$

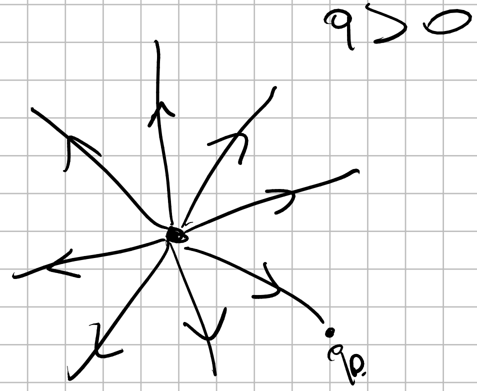
$q_2 > 0$, $q_1 < 0$

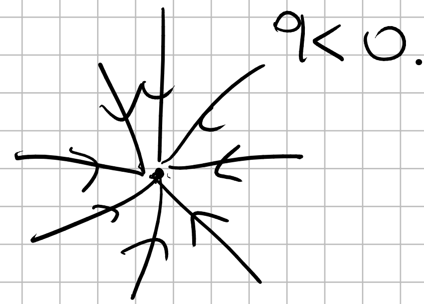
- vale il principio di sovrapposizione

$$\vec{F}_{TOT} = \sum_{i}^{N} \vec{F}_i$$

- campo elettrico

$$\vec{E} = \frac{\vec{F}_e}{q_0}$$





anche per il campo elettrico vale principio di sovrapposizione.

$$\vec{E}_{TOT} = \sum_{i}^{N} \vec{E}_i$$

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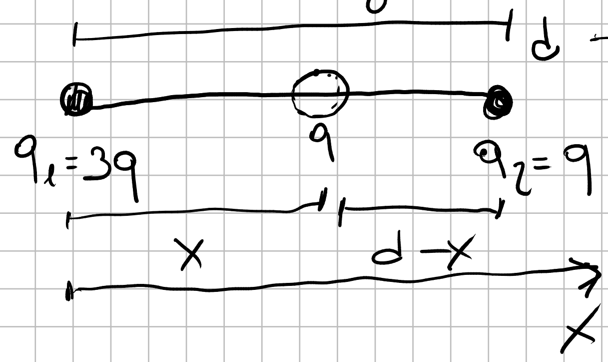
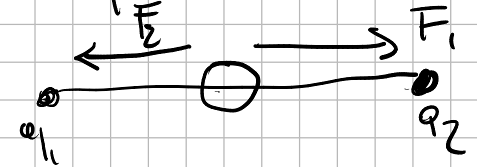


$d = 1{,}5\ m$

Qual'è la posizione di equilibrio della sfera libera di muoversi.

- per trovare condizione di equilibrio deve essere

$$\vec{F}_{TOT} = \vec{F}_1 + \vec{F}_2 = 0$$



$$\cancel{k_e} \cdot \frac{3\cancel{q} \cdot \cancel{q}}{x^2} - \cancel{k_e} \frac{\cancel{q} \cdot \cancel{q}}{(d-x)^2} = 0 \longrightarrow \frac{3}{x^2} - \frac{1}{(d-x)^2} = 0$$

sappiamo $0 < x < d$

moltiplico ambi i lati per $x^2 (d-x)^2$

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

$$3(d-x)^2 = x^2$$

perché $0<x<d$ non abbiamo soluzioni negative, prendiamo solo le radice

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

$$\downarrow \quad x\left(1+\frac{1}{\sqrt{3}}\right) = d$$

$$x = \frac{d}{\left(1+1/\sqrt{3}\right)}$$

$$d = 1{,}5\ m$$

$$x \sim 0{,}951\ m$$

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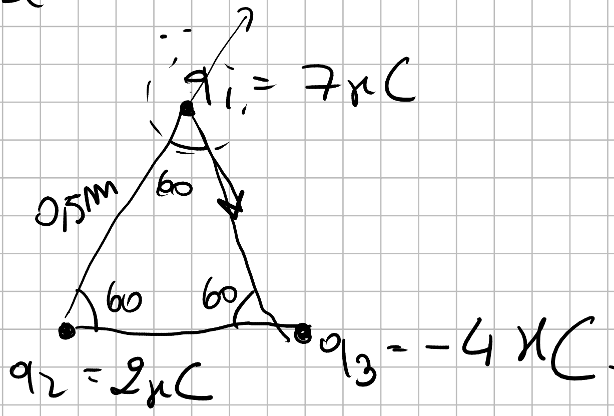
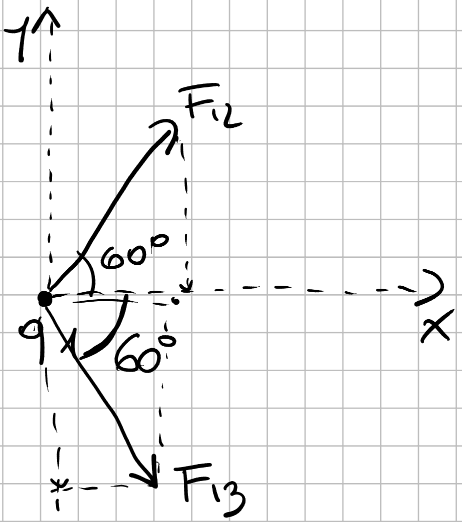
Si tiene di 3 cariche ai vertici di triangolo equilatero.

lato del triangolo è 0,5 m

? determinare la forza totale su q_1





Scompongo su x e y

$$F_x = F_{12} \cdot \cos 60^\circ + F_{13} \cos 60^\circ$$

$$F_y = F_{12} \cdot \sin 60^\circ + F_{13} \sin 60^\circ$$

$$F_{12} \downarrow k_e \frac{q_1 q_2}{r^2}$$

$$F_x = k_e \cdot \frac{7 \cdot 10^{-6} \cdot 2 \cdot 10^{-6}}{(0{,}15)^2} \cdot \frac{1}{2} + k_e \frac{4 \cdot 10^{-6} \cdot 7 \cdot 10^{-6}}{(0{,}15)^2} \cdot \frac{1}{2}$$

$$F_y = k_e \cdot \frac{7 \cdot 10^{-6} \cdot 2 \cdot 10^{-6}}{(0{,}15)} \cdot \frac{\sqrt{3}}{2} - \frac{k_e\, 4 \cdot 10^{-6} \cdot 7 \cdot 10^{-6}}{(0{,}15)} \cdot \frac{\sqrt{3}}{2}$$

$$\begin{cases} F_x = 0{,}753 \text{ N} \\ F_y = -0{,}436 \text{ N} \end{cases}$$

$\downarrow$ se vogliamo riesprimerlo come vettore

$$\boxed{\vec{F} = (0{,}755 \text{ N})\,\hat{i} + (-0{,}436 \text{ N})\,\hat{j}}$$

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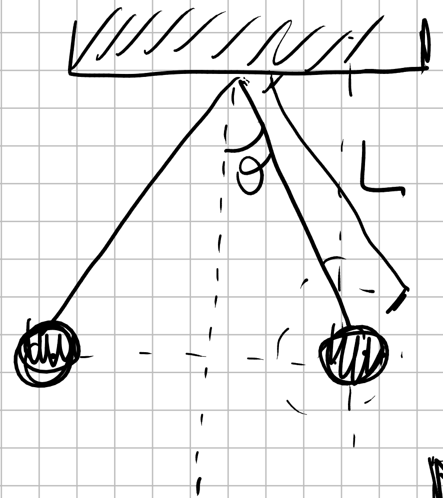
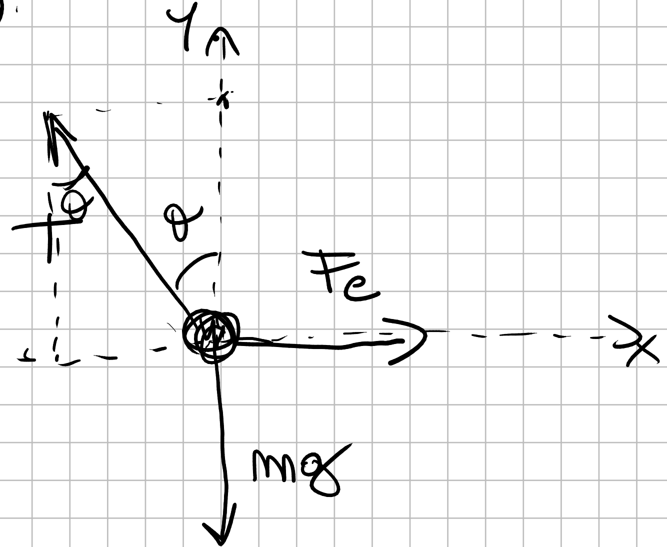


$\theta = 5^\circ$

$q = 7\,mC$

$m = 0{,}2\,g$

$L = ?$



$$\begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \end{cases}$$

$$\begin{cases} F_e - T \cdot \sin\theta = 0 \\ T \cdot \cos\theta - mg = 0 \end{cases}$$

$$T = \frac{mg}{\cos\theta}$$

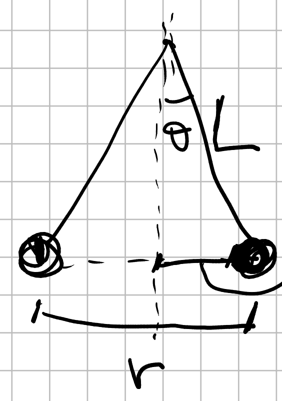
$$F_e - \overbrace{\frac{mg}{\cos\theta}}^{T} \cdot \operatorname{sen}\theta = 0$$

$$\frac{\operatorname{sen}\theta}{\cos\theta} = \tan\theta$$

$$F_e - mg\tan\theta = 0$$

quindi vale F_e?

$$F_e = \frac{K \cdot q_1 q_2}{r^2}$$



$L\operatorname{sen}\theta$

$r = 2L\operatorname{sen}\theta$

$$\frac{k_e \, q^2}{(2L\sin\theta)^2} - mg\tan\theta = 0$$

$$\frac{k_e q^2}{(2L\sin\theta)^2} = mg\tan\theta$$

$$(2L\sin\theta)^2 = \frac{k_e q^2}{mg\tan\theta}$$

$$2L\sin\theta = \sqrt{\frac{k_e q^2}{mg\tan\theta}} \longrightarrow L = \frac{1}{2\sin\theta} \cdot \sqrt{\frac{k_e q^2}{mg\tan\theta}}$$

P

$\sin 5^\circ = 0{,}0871$

$\tan 5^\circ = 0{,}08748$

$m = 0{,}2\,g \rightarrow 0{,}2 \cdot 10^{-3}\,kg$

$$L = \frac{1}{2\sin\theta} \cdot \sqrt{\frac{k_e q^2}{mg\tan\theta}}$$

$$L = \frac{1}{2 \cdot 0{,}0871} \cdot \sqrt{\frac{9 \cdot 10^{9} \cdot (7{,}2 \cdot 10^{-9})^2}{(0{,}2 \cdot 10^{-3}) \cdot 9{,}8 \cdot 0{,}08748}} = 0{,}299\,m$$

$$\vec{E} = \frac{\vec{F}_e}{q_p}$$

$$\vec{E} = k_e \frac{q}{r^2} \hat{r} \longrightarrow \vec{E} = \sum_i^N \frac{k_e q_i}{r_i^2} \hat{r}_i \rightsquigarrow \left(\vec{E} = k_e \int \frac{dq}{r^2} \hat{r} \right)$$

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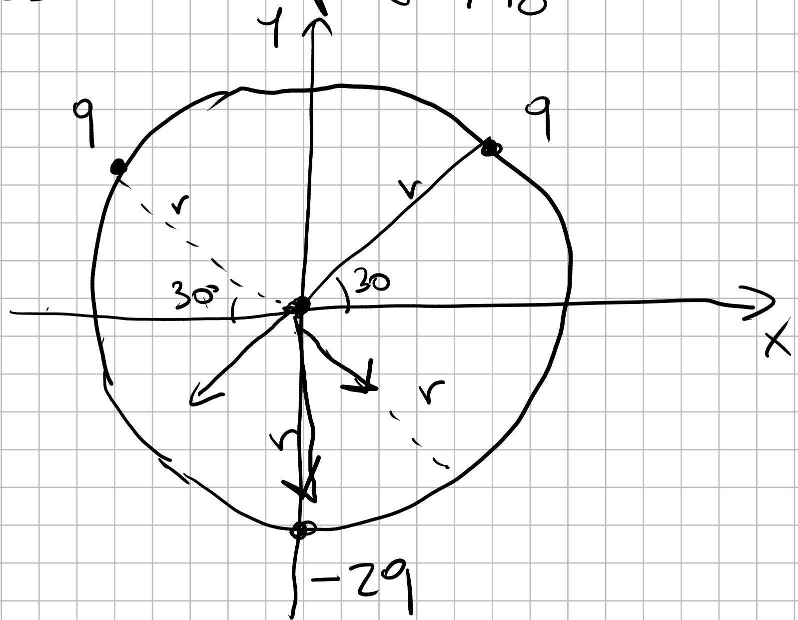
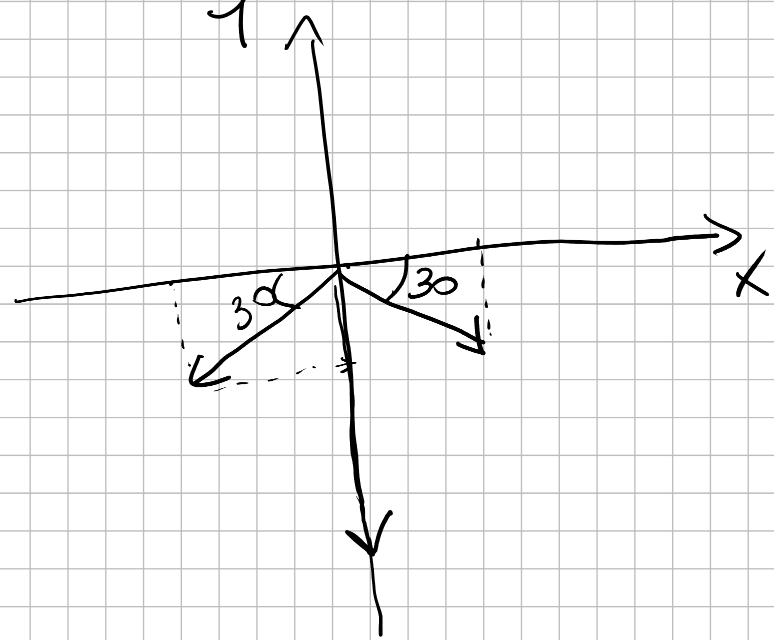
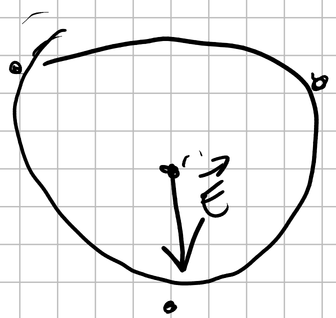


circonferenza ha raggio r

determinare il campo elettrico

E(0,0)





$$E_x = \frac{k_e q}{r^2} \cdot \cos 30^\circ - \frac{k_e q}{r^2} \cos 30^\circ = 0$$

$$E_y = -\frac{2k_e q}{r^2} - \frac{k_e q \, \overbrace{\operatorname{sen} 30^\circ}^{1/2}}{r^2} - \frac{k_e q \, \overbrace{\operatorname{sen} 30^\circ}^{1/2}}{r^2}$$

$$E_y = -\frac{3k_e q}{r^2} \qquad \vec{E} = -\frac{3k_e q}{r^2}\,\hat{j}$$

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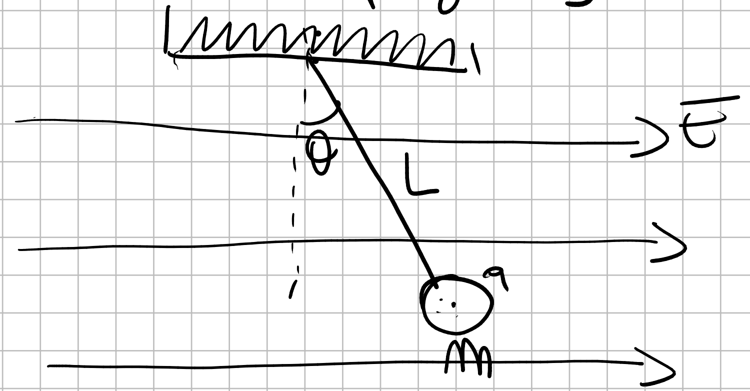


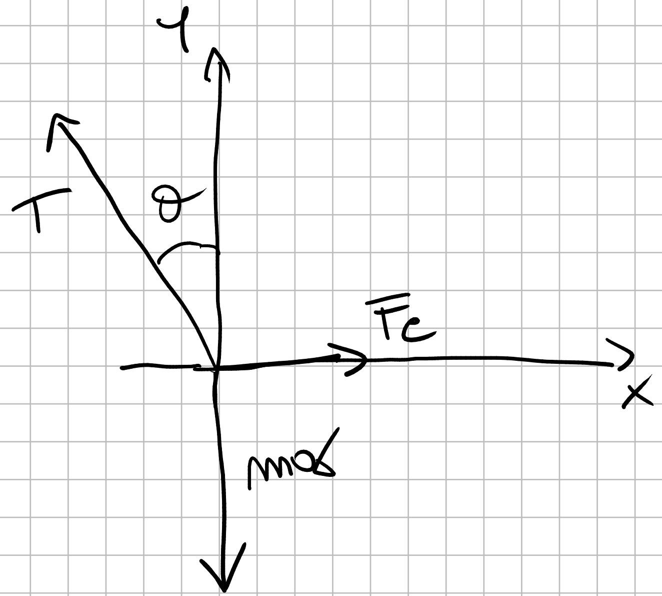
$E = 10^3 \; N/C$

$L = 20 cm$

$m = 20 g$

$\theta = 15°$

$q = ?$



$$\begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \end{cases}$$

$$\begin{cases} F_e - T \operatorname{sen}\theta = 0 \\ T\cos\theta - mg = 0 \end{cases}$$

$$T = \frac{mg}{\cos\theta}$$

$$\vec{E} = \frac{\vec{F}}{q} \qquad \vec{F_e} = q\vec{E}$$

$$F_e = mg \cdot \tan\theta$$

$$qE = mg\tan\theta \longrightarrow q = \frac{mg\tan\theta}{E}$$

$\theta = 15^\circ$

$\tan\theta = 0{,}268$

$$q = \frac{2 \cdot 10^{-3} \cdot 9{,}8 \cdot 0{,}268}{10^{3}} = 2 \cdot 9{,}8 \cdot 0{,}268 \cdot 10^{-6} = 5{,}25 \cdot 10^{-6}\,C$$

$$= 5{,}25\,\mu C$$

Moto di una carica in campo elettrico. [guardare anche soli ES 23.11 pag 712]

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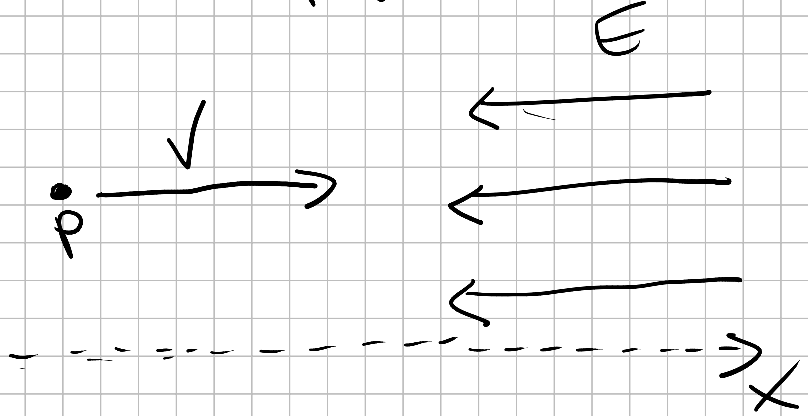

$E = -6 \cdot 10^{5}$ N/C uniforme.

il protone percorre 7 cm prima di fermarsi.

$x_f = 7$ cm $\quad v_f = 0 \quad$ massa

$a = ? \quad v_i = ? \quad t_f = ?$

Sapendo che

$m_p = 1{,}672 \cdot 10^{-27}$ Kg

$q_p = 1.6 \cdot 10^{-19}$ C

$$\begin{cases} F = q_p \cdot E \\ F = m_p a \end{cases}$$

$$a = \frac{q_p \cdot E}{m_p}$$

$$= \frac{1.6 \cdot 10^{-19} \cdot (-6 \cdot 10^{5})}{1{,}672 \cdot 10^{-27}}$$

$$= -\frac{1{,}6 \cdot 6}{1{,}672} \cdot 10^{13} = -5{,}74 \cdot 10^{13} \, m/s^2$$

$$\begin{cases} x_f = \frac{1}{2} a t^2 + v_i t + x_i \\ v_f = v_i + a t \end{cases}$$

$$t = \frac{v_f - v_i}{a}$$

$$x_f = \frac{1}{2} a \left(\frac{v_f - v_i}{a} \right)^2 + v_i \left(\frac{v_f - v_i}{a} \right) + x_i$$

$$x_f = \frac{1}{2} \cancel{a} \frac{(v_f - v_i)^2}{a \cancel{^2}} + v_i \frac{(v_f - v_i)}{a} + x_i$$

$$2a(x_f - x_i) = v_f^2 + v_i^2 - \cancel{2v_f} v_i + \cancel{2v_f} v_i - 2v_i^2$$

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

$v_f \to 0$, $a \to -5{,}76 \cdot 10^{13}$, $x_f \to 0{,}07$, $x_i \to 0$

$$v_i^2 + 2 \cdot (-5{,}76 \cdot 10^{13}) \cdot 0{,}07 = 0$$

$$v_i^2 = 0{,}14 \cdot 5{,}76 \cdot 10^{13} \qquad v_i = 2{,}84 \cdot 10^6 \text{ m/s}$$

$$V_f = V_i + at$$

$$\underset{0}{\underbrace{V_f}} = \underset{2.84\cdot 10^{6}}{\underbrace{V_i}} + at$$

$$0 = 2.84\cdot 10^{6} + \left(-5{,}76\cdot 10^{13}\right)\cdot t_f$$

$$t_f = \frac{2{,}84\cdot 10^{6}}{+5{,}76\cdot 10^{13}} \longrightarrow t_f = 4{,}93\cdot 10^{-8}\ s$$