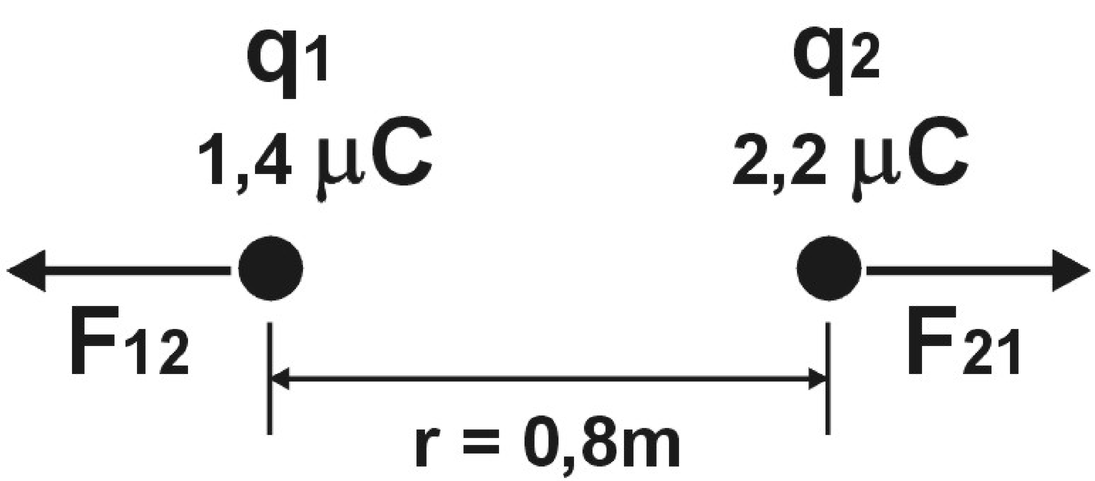
$\varepsilon_0 = 8{,}85418 \times 10^{-12}\ Coul^2/N\text{-}m^2$ = permitividad del vacío.

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \frac{N\text{-}m^2}{Coul^2}$$



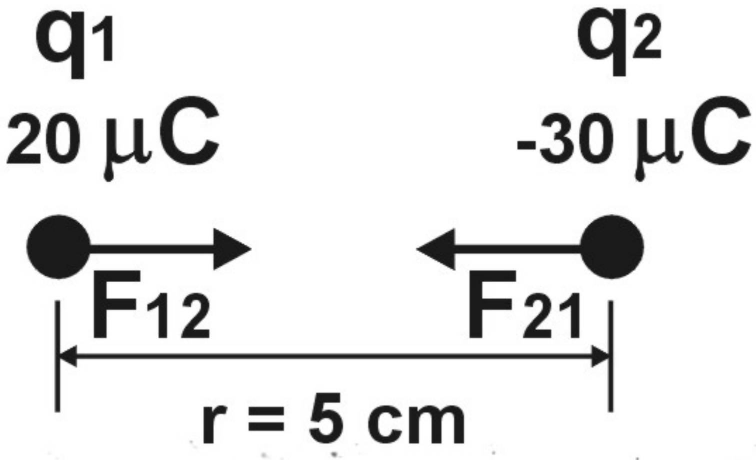
$$\vec{F}_{12} = \vec{F}_{21} = \vec{F}$$

$$F = \frac{1}{4\pi\varepsilon_0}\,\frac{q_1 q_2}{r^2}$$

$$F = 9 \times 10^9\ \frac{N\text{-}m^2}{Coul^2} \times \frac{1{,}4 \times 10^{-6}\,Coul \times 2{,}2 \times 10^{-6}\,Coul}{(0{,}8)^2\,m^2} = 0{,}043\ N$$

$$\boxed{F = 0{,}043\,N}$$

COULOMB SOLUCIÓN 2



$q_1 = 20\mu C$; $r = 5cm$

$q_2 = -30\mu C$

$\frac{1}{4\pi\varepsilon_0} = 9\times10^9 \frac{N.m^2}{Coul^2}$

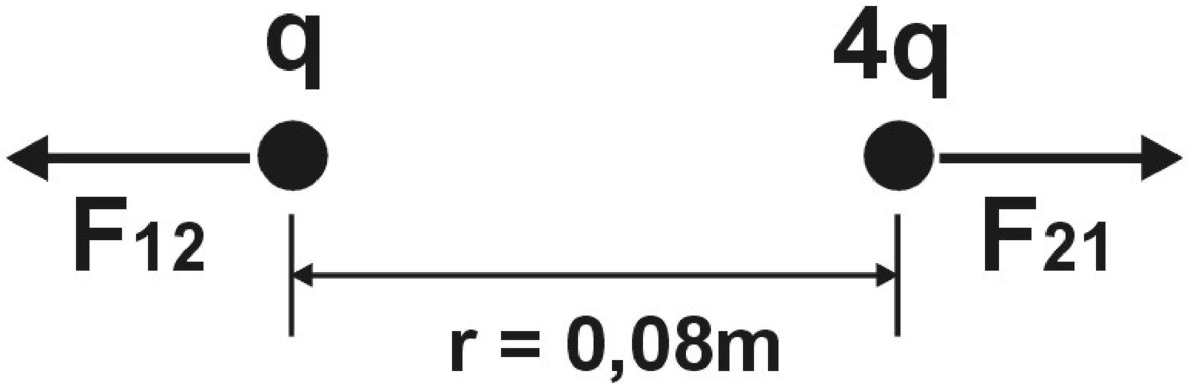
$F_{12} = F_{21} = F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2} \Rightarrow$

$F = 9\times10^9 \frac{Nm^2}{C^2} \times \frac{20\times10^{-6}\times|30\times10^{-6}|\,C^2}{(0{,}05)^2 m^2}$

$\therefore\ \boxed{F = 2160\ N}$

COULOMB SOLUCIÓN 5

$$\frac{1}{4\pi\varepsilon_0} = 9.10^9 \frac{C^2}{N.m^2}$$



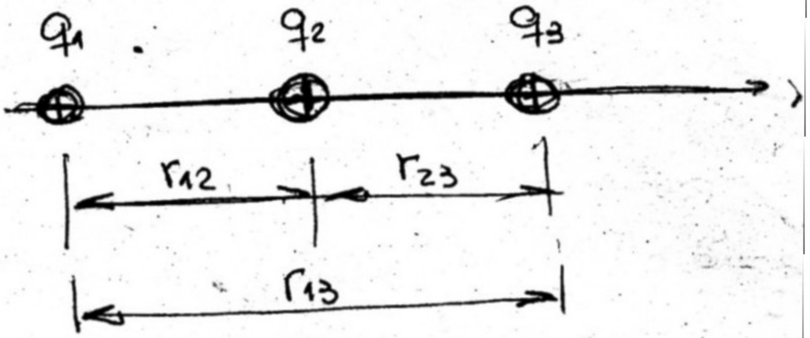
$q_1 = q$

$q_2 = 4.q$

$r = 0,08m$

$$0,225\ N = 9.10^9 \frac{C^2}{N.m^2} \frac{4.q^2}{(0,08\ m)^2} \Rightarrow \begin{cases} q_1 = 0,2\ \mu C \\ q_2 = 0,8\ \mu C \end{cases}$$

6) SUPERPOSICIÓN DE FUERZAS



$q_1 = 20\mu C$

$q_2 = 10\mu C$

$q_3 = 30\mu C$

$r_{12} = 0{,}1m \quad r_{23} = 0{,}1m$

$r_{13} = 0{,}2\, m$

$$F_{13} = 9\times10^9 \frac{Nm^2}{C^2} \times \frac{(20\times30)\times10^{-12}\, C^2}{(0{,}2\, m)^2} = 135\, N = F_{13} = F_{31}$$

$$F_{12} = 9\times10^9 \frac{Nm^2}{C^2} \times \frac{(20\times10)\times10^{-12}\, C^2}{(0{,}1\, m)^2} = 180\, N = F_{12} = F_{21}$$

$$F_{23} = 9\times10^9 \frac{Nm^2}{C^2} \times \frac{(10\times30)\, 10^{-12}\, C^2}{(0{,}1\, m)^2} = 270\, N = F_{23} = F_{32}$$

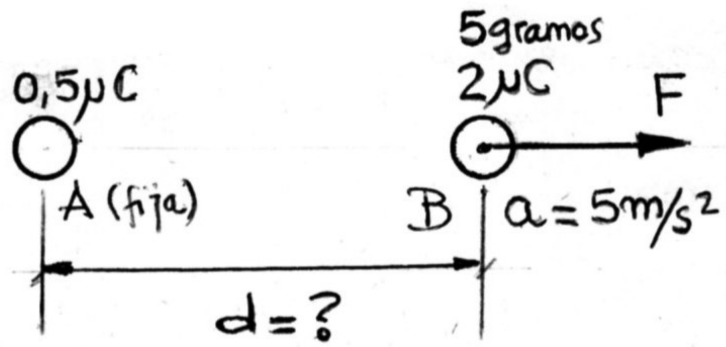
$$\vec{F_1} = \vec{F_{12}} + \vec{F_{13}} = (180N + 135\, N)(-\check{i}) = 315\, N(-\check{i}) \rightarrow \boxed{\vec{F_1} = -315\, N\, \check{i}}$$

$$\vec{F_2} = \vec{F_{21}} + \vec{F_{23}} =$$

$$\vec{F_2} = 180\, \check{i} - 270\, \check{i} = -90\, N\, \check{i} \rightarrow \boxed{\vec{F_2} = -90\, N\, \check{i}}$$

$$\vec{F_3} = \vec{F_{31}} + \vec{F_{32}} = 135\, N\, \check{i} + 270\, N\, \check{i} = 405\, N\, \check{i} \rightarrow \boxed{\vec{F_3} = 405\, N\, \check{i}}$$

El cuerpo B (sistema) experimenta una fuerza de origen Coulombiano



$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_A q_B}{d^2}$$

dado que posee Carga Eléctrica q_B

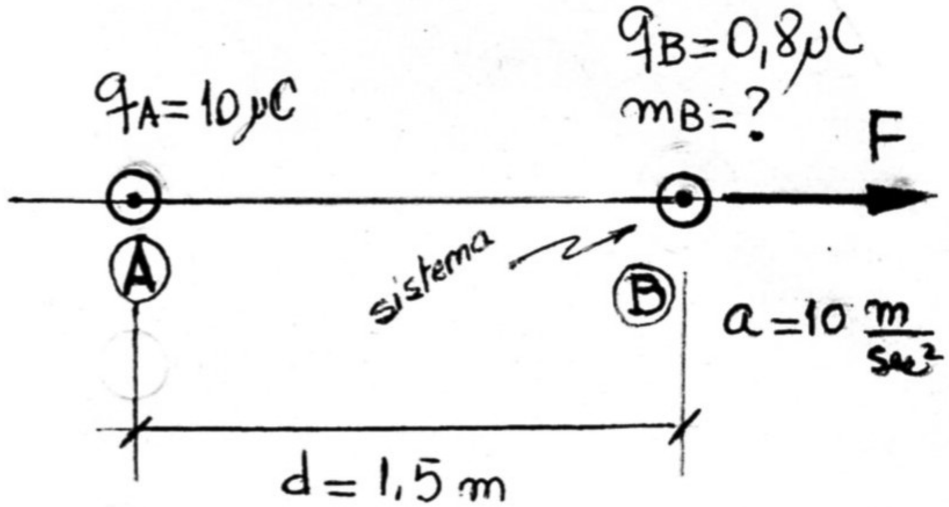
y además se encuentra en las cercanías del cuerpo A que posee carga q_A - que forma parte del medio ambiente.

Pero el cuerpo B, además de carga tiene masa $m_B = 0{,}005\ Kg$ y por lo tanto, según Newton, esa fuerza Coulombiana F, hará que B acelere con $a = \frac{F}{m_B}$. Es decir que

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_A q_B}{d^2} = m_B a \Rightarrow d = \sqrt{\frac{q_A q_B}{4\pi\varepsilon_0\, a\, m_B}}$$

$$\therefore d = \sqrt{9 \times 10^9 \frac{Nm^2}{C^2} \times \frac{0{,}5 \times 10^{-6} \times 2 \times 10^{-6}\ C^2}{5\ m/seg^2 \times 5 \times 10^{-3}\ Kg}} = 0{,}6\ m.$$

$$\therefore \boxed{d = 0{,}6\,m = 60\ cm}$$



Según Newton

$$m_B = \frac{F}{a}$$

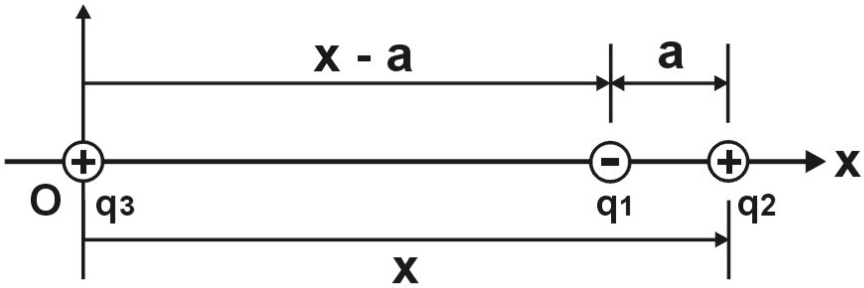
Conocemos "a" pero no conocemos "F" que q_A ejerce sobre q_B (sistema).-

La "F" es de origen Coulombiano

$$\therefore F = 9 \times 10^9 \frac{Nm^2}{C^2} \times \frac{10 \times 10^{-6} C \times 0{,}8 \times 10^{-6} C}{(1{,}5\,m)^2} = \boxed{0{,}032\,N = F}$$

$$\therefore m_B = \frac{0{,}032\,N}{10\ m/seg^2} = 0{,}0032\ Kg \Rightarrow \boxed{m_B = 3{,}2\,g}$$

$q_1 = -4\,\mu C$
$q_2 = 6\,\mu C$
$q_3 = 2\,\mu C$
$r_{12} = a = 0{,}1m$
$r_{23} = x$
$r_{13} = x - a$



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

$$\frac{|4|_x|2|}{(x-a)^2} = \frac{|6||2|}{x^2} \Rightarrow \frac{(x-a)^2}{8} = \frac{x^2}{12} \Rightarrow \frac{3}{2}\cdot(x-a)^2 = x^2$$

$$3\cdot(x-a)^2 = 2x^2$$

$$3(x^2 - 2ax + a^2) = 2x^2 \therefore \quad 3x^2 - 2x^2 - 6ax + 3a^2 = 0 \therefore$$

$$x^2 - 6ax + 3a^2 = 0 \Rightarrow x^2 - 0{,}6x + 0{,}03 = 0.$$

Se resuelve la cuadrática y resulta $x_1 = 0{,}545\,m$ ← ✓

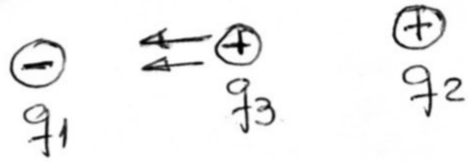
$x_2 = 0{,}045\,m$ ← NO

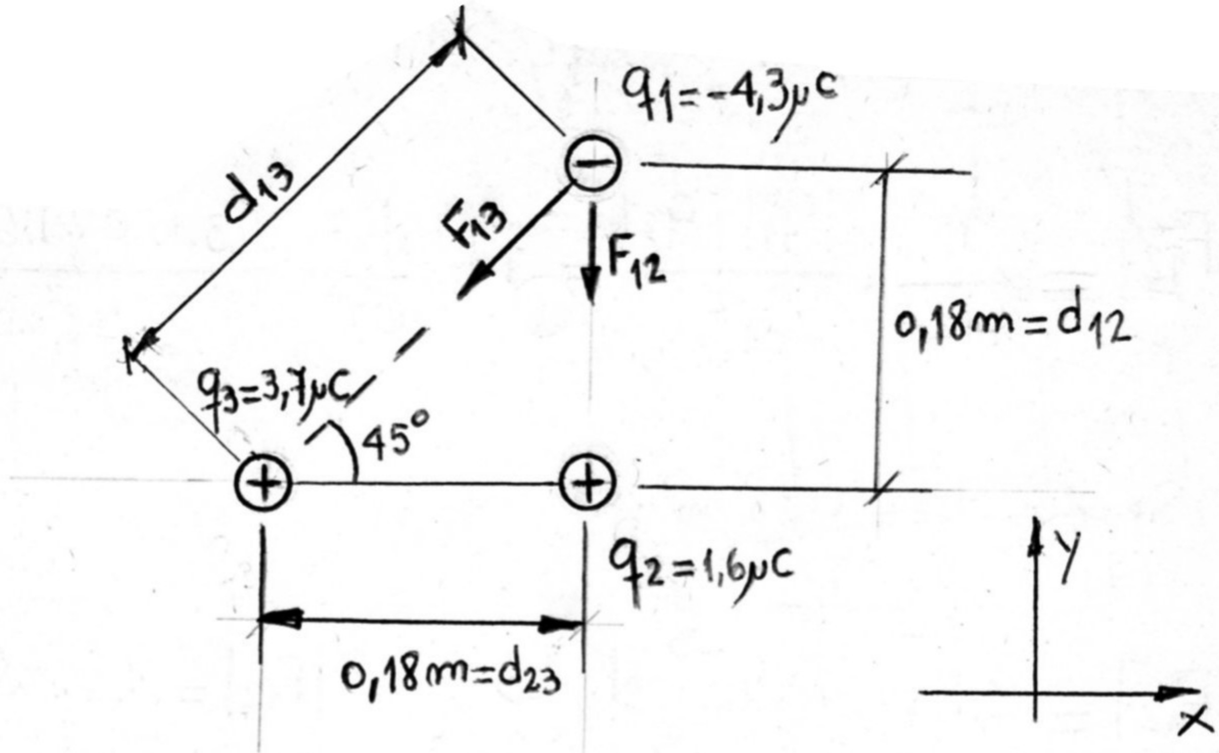
La solución correcta es

$\boxed{x = 0{,}545\,m = 54{,}5\,cm}$ ← CORRECTA.

(*) La otra solución debe descartarse ya que si la carga q_3 estuviese a 4,5cm de q_2, la q_3 estaría entre medio de q_1 y q_2.

Esto hace imposible la cancelación de fuerzas sobre q_3.





∘) <u>Acción de q_3 sobre q_1</u> : F_{13}.

$$|F_{13}| = \frac{1}{4\pi\varepsilon_0} \cdot \frac{|q_1||q_3|}{d_{13}^2} = 9 \times 10^9 \frac{N \cdot m^2}{C^2} \times \frac{4{,}3 \times 10^{-6} C \times 3{,}7 \times 10^{-6} C}{d_{13}^2}$$

donde $d_{13}^2 = 0{,}18^2 + 0{,}18^2 = 0{,}065\ m^2$.

$$\therefore |F_{13}| = \frac{9 \times 4{,}3 \times 3{,}7}{0{,}065} \times 10^{-3} = 2202{,}92 \times 10^{-3}\ N \therefore$$

$$\boxed{|F_{13}| \simeq 2{,}2\ N} \Rightarrow \begin{cases} F_{13}y = 2{,}2\ N \times \cos 45^\circ (-\check{j}) \\ F_{13}x = 2{,}2\ N \times \operatorname{sen} 45^\circ (-\check{i}) \end{cases}$$

$$\boxed{\begin{array}{l} F_{13}y = -1{,}56\ \check{j}\ N \\ F_{13}x = -1{,}56\ \check{i}\ N \end{array}}$$

·) Acción de q_2 sobre q_1 : F_{12}

$$|F_{12}| = \frac{1}{4\pi\varepsilon_0} \cdot \frac{|q_1||q_2|}{d_{12}^2} = 9 \times 10^9 \frac{N m^2}{C^2} \cdot \frac{4{,}3 \times 10^{-6} C \times 1{,}6 \times 10^{-6} C}{0{,}18^2 m^2}$$

Siendo $d_{12}^2 = 0{,}18^2 m^2$.

$$|F_{12}| = 1911{,}1 \cdot \times 10^{-3} N. \Rightarrow \quad |F_{12}| = 1{,}91 N$$

$$\boxed{F_{12} = -1{,}91 \check{j} N}$$

·) Σ Fuerzas.

$$\vec{F} = \vec{F_{12}} + \vec{F_{13}} = -1{,}91 \check{j} + (-1{,}56) \check{j} - 1{,}56 \check{i}$$

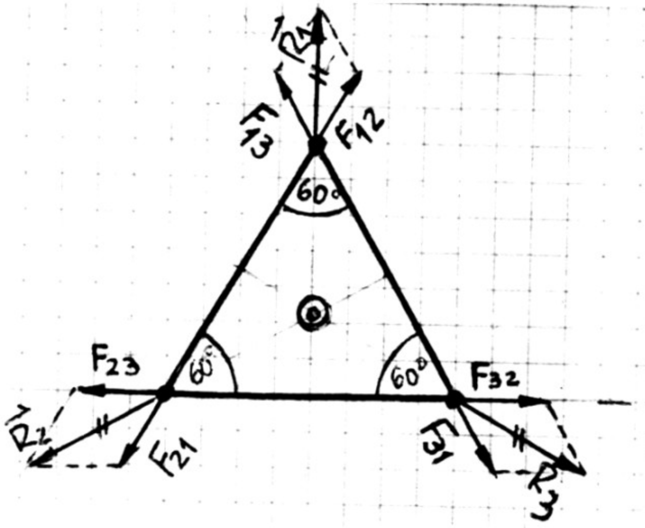
$$= \boxed{-1{,}56 \check{i} - 3{,}47 \check{j} = \vec{F}}$$

DATOS:

$q_1 = q_2 = q_3 = -1{,}6 \times 10^{-19}\,C$ (carga del electrón).

$r_{12} = r_{13} = r_{23} = a = 3\,cm$ (0,03 m).

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \frac{N\,m^2}{C^2}$



1) Fuerza de Repulsión entre Cargas vértice

$|F_{12}| = |F_{13}| = |F_{23}| = |F_R|$ siendo

$$|F_R| = \frac{1}{4\pi\varepsilon_0} \times \frac{q_i\,q_j}{(r_{ij})^2} = 9 \times 10^9\ \frac{N\,\cancel{m^2}}{\cancel{C^2}} \times \frac{(1{,}6 \times 10^{-19})^2\,\cancel{C^2}}{(3 \times 10^{-2})^2\,\cancel{m^2}} = 2{,}56 \times 10^{-25}\,N \quad \therefore \boxed{|F_R| = 2{,}56 \times 10^{-25}\,N}$$

2) SUPERPOSICIÓN VECTORIAL SOBRE UN EJE DE SIMETRÍA

Cada carga q_i "sentirá" una fuerza resultante R de Repulsión, que resulta de hacer:

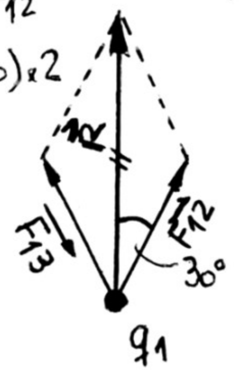
$\vec{R} = \vec{F_{13}} + \vec{F_{12}}$ $\qquad |\vec{F_{13}}| = |\vec{F_{12}}| = F$

$|\vec{R}| = (F \cos 30) \times 2$

$|R| = 2\,|F_R| \cos 30° =$

$= 2 \times 2{,}56 \times 10^{-25} \times 0{,}866 = 4{,}43 \times 10^{-25}\,N$

$\boxed{|R| = 4{,}43 \times 10^{-25}\,N}$



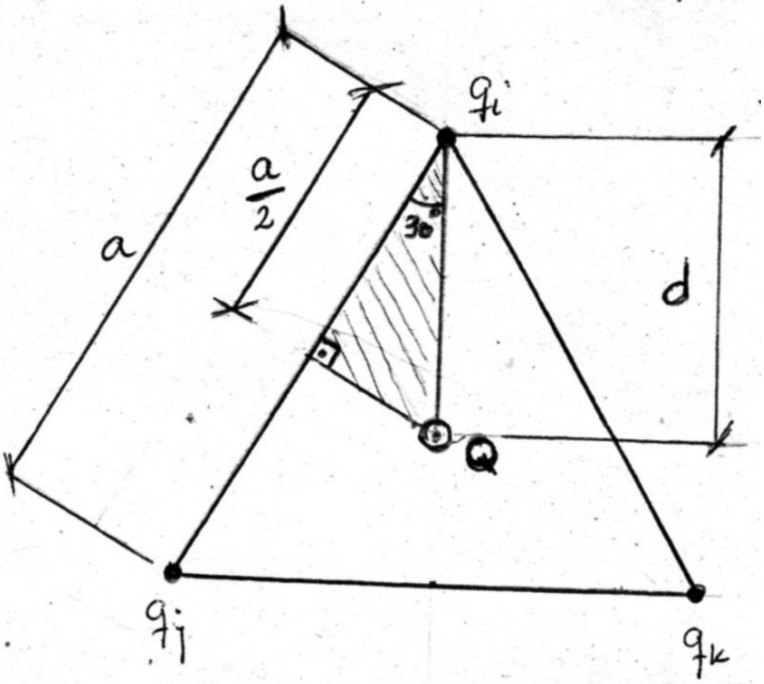
3) CARGA Q (POSITIVA)

•) La carga Q se ubica a una distancia "d" de c/una de las cargas q_i, siendo

$$d = \frac{a/2}{\cos 30°}$$

$$\therefore d = \frac{3\,cm/2}{0{,}866} = 1{,}73\,cm.$$

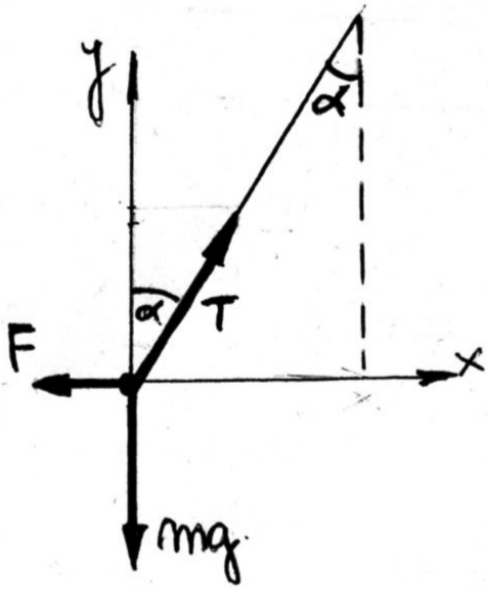
$$\therefore \boxed{d = 1{,}73 \times 10^{-2}\,m}$$

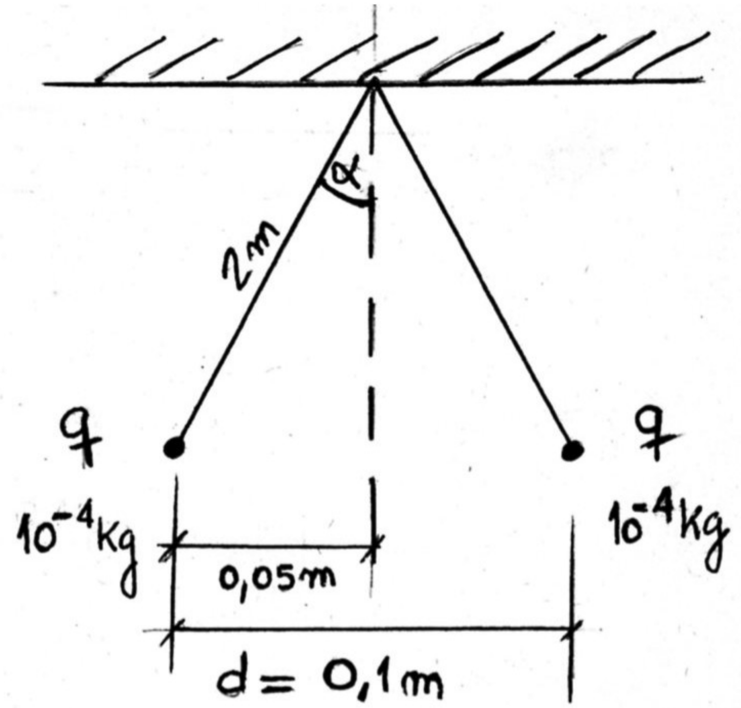


•) La fuerza que la carga Q produce sobre las q_i de los vertices es igual y de signo opuesto a la resultante $|F_{RA}| = 4{,}43 \times 10^{-25}\,N$. $\therefore |F_Q| = |F_{RA}|$.

$$\therefore F_Q = \frac{1}{4\pi\varepsilon_0} \times \frac{q_i Q}{d^2} \Rightarrow Q = \frac{F_Q \times d^2}{q_i} \cdot \left(\frac{4\pi\varepsilon_0}{1}\right) =$$

$$\therefore Q = \frac{4{,}43 \times 10^{-25} \times (1{,}73 \times 10^{-2})^2}{1{,}6 \times 10^{-19} \times 9 \times 10^9}\,C \Rightarrow \boxed{Q = 9{,}207 \times 10^{-20}\,C}$$





El ÁNGULO α :

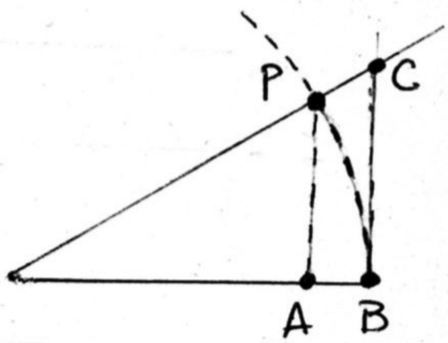
Con las dimensiones dadas podemos calcular el Sen $\alpha = \dfrac{0{,}05\ m}{2\ m}$

$\therefore$ Sen $\alpha = 0{,}025 \Rightarrow \alpha = 1{,}4325^\circ$ sexagesimales

Expresado en radianes queda 360° — 2π radianes

$1{,}4325^\circ$ — x $\Rightarrow \boxed{x = 0{,}025}$

$\therefore\ \alpha = 1{,}4325^\circ = 0{,}025$ radianes.



Calculemos $\operatorname{tg}\alpha = \operatorname{tg}(1{,}4325^\circ) = 0{,}025$.

$\therefore\ \boxed{\alpha = 1{,}4325^\circ = \underbrace{0{,}025\ rad}_{\text{Arco} \cong \overline{BP}} \cong \underbrace{\text{Sen}\,\alpha}_{\text{CATETO } \overline{PA}} \cong \underbrace{\operatorname{tg}\alpha}_{\text{CATETO } \overline{BC}}} \rightarrow$ Se cum

Por Ley de Coulomb $\equiv F = \frac{1}{4\pi\varepsilon_0}\frac{q\,q}{d^2} = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{d^2}$ dado que ambas cargas son iguales a "q".

$$\Rightarrow \quad q = \sqrt{4\pi\varepsilon_0 d^2 \times F} = \sqrt{\frac{(0{,}1\,m)^2 \times F}{9\times10^9\ \frac{N\,m^2}{C^2}}}$$

El problema es que aún no conocemos F:

Para conocerla apelamos al diagrama de cuerpo aislado:

<u>Equilibrio</u>:

$$\left.\begin{array}{l} T\cos\alpha - mg = 0 \\ T\operatorname{sen}\alpha - F = 0 \end{array}\right\} \Rightarrow \boxed{F = mg\,tg\,\alpha}$$

$$F = mg\,tg\,\alpha \cong mg\alpha = 10^{-4}\,Kg \times 10\,\frac{m}{seg^2} \times 0{,}025$$

$$F = 25\times10^{-6}\,N.$$

Introducimos el valor de F en la expresión de q y queda:

$$q = \sqrt{\frac{0{,}1^2 \times 25\times10^{-6}}{9\times10^9}} = \frac{5}{3}\cdot\sqrt{10^{-2}\cdot10^{-6}\times10^{-9}} = \frac{5}{3}\sqrt{10^{-17}} =$$

$$\frac{5}{3}\times3{,}16\times10^{-9}\,C = 5{,}27\,nC \qquad \boxed{q = 5{,}27\,nC}$$