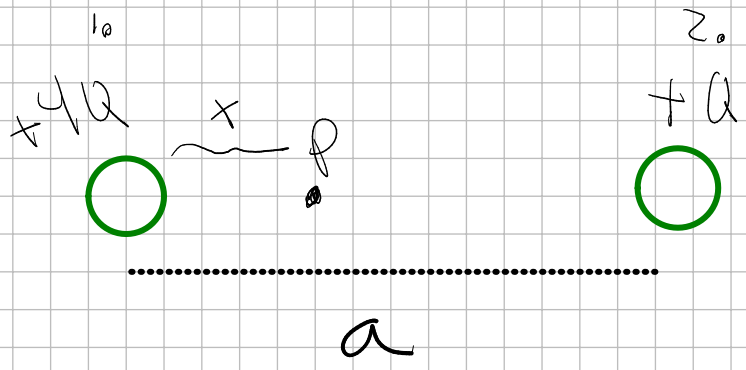
Eksamen, Nikolai H. Brandt, 2022
Øving 6.



(1) $E_P = 0$

$$E_P = \frac{F_1}{Q_P} - \frac{F_2}{Q_P}$$

$$0 = \frac{k\,4Q\,Q_P}{x^2\,Q_P} - \frac{k\,Q\,Q_P}{(a-x)^2\,Q_P}$$

$$\frac{k\,4Q}{x^2} = \frac{k\,Q}{(a-x)^2}$$

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

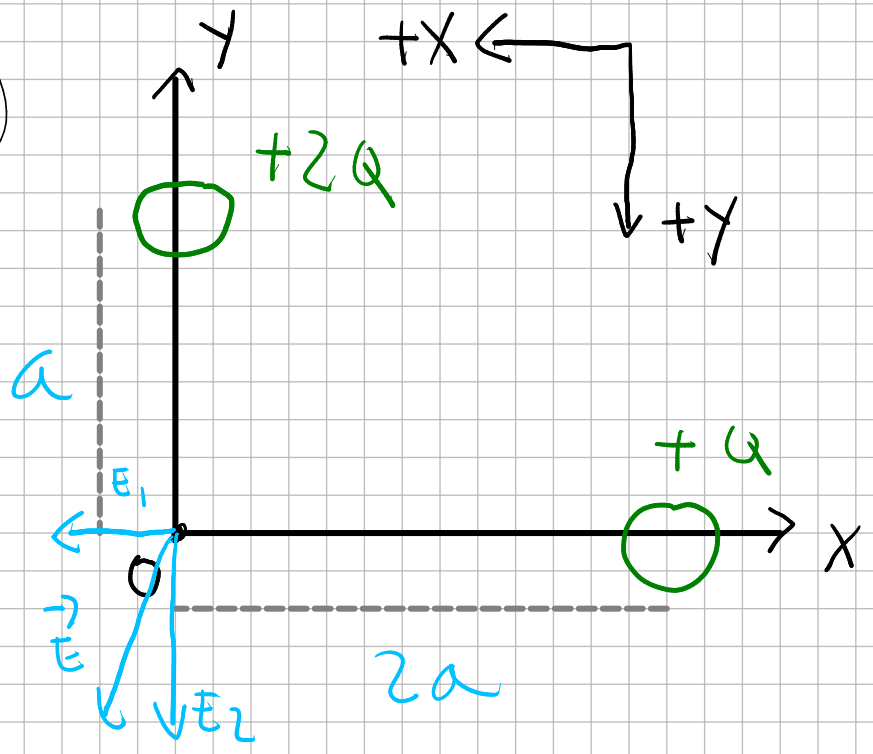
$$x^2 = 4(a-x)^2$$

$$x = 2(a-x)$$

$$x = 2a - 2x$$

$$x = \frac{2}{3}a$$

(2)



Ladning i origo: q

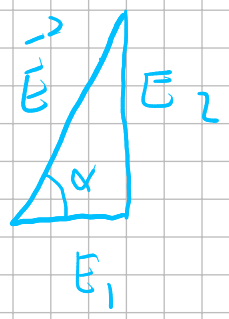
$$E_1 = \frac{F_1}{q} = \frac{kQq}{q4a^2} = \frac{kQ}{4a^2}\uparrow$$

$$E_2 = \frac{F_2}{q} = \frac{k2Qq}{4a^2} = \frac{2kQ}{a^2}\hat{j}$$

$$\vec{E} = \left[\frac{kQ}{4a^2}\uparrow + \frac{2kQ}{a^2}\hat{j}\right]$$

$$|E| = \sqrt{E_1^2 + E_2^2} = \sqrt{\frac{k^2Q^2}{16a^4} + \frac{4k^2Q^2}{a^4}}$$

$$= \sqrt{\frac{k^2Q^2}{a^4}\left(\frac{1}{16} + 4\right)} = \frac{kQ}{a^2}\frac{\sqrt{65}}{4}$$



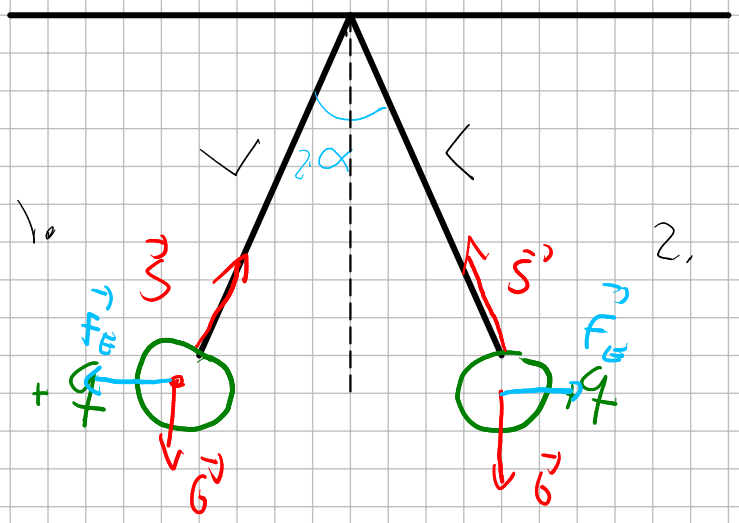
$$\tan\alpha = \frac{E_2}{E_1}$$

$$\alpha = \arctan\left(\frac{E_2}{E_1}\right) = \frac{\frac{2kQ}{a^2}}{\frac{kQ}{4a^2}}$$

$$= \arctan(8) = \underline{82{,}9^\circ}$$

(3)

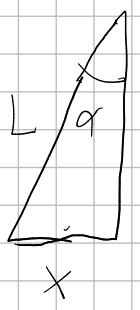
a)



$\alpha = 25^\circ$

$L = 1{,}2\,m$

$m = 0{,}015\,kg$



$\sin\alpha = \frac{x}{L}$

$x = \sin\alpha L$

Ser på kule 1.

$$\sum f_x = 0$$

$$\vec{f_E} - S_x = 0$$

$$\frac{kq^2}{(2x)^2} = \vec{S_x}$$

$$\tan\alpha = \frac{S_x}{S_y}$$

$$\sum F_y = 0$$

$$\vec{G} = \vec{S_y}$$

$$S_x = \tan\alpha \quad S_y = \tan\alpha\, mg$$

$$kq^2 = \tan\alpha \cdot mg \cdot 4\sin^2\alpha L^2$$

$$q = 2L\sin\alpha\sqrt{\frac{\tan\alpha mg}{k}}$$

$$q = 2 \cdot 1{,}2\,m \cdot \sin(28°) \cdot \sqrt{\frac{\tan(28°) \cdot 0{,}015\,kg \cdot 9{,}81\,m/s^2}{8{,}99 \cdot 10^9 \frac{Nm^2}{C^2}}}$$

$$\underline{q = 2{,}8 \cdot 10^{-6}\,C}$$

b) $kq^2 = \tan\alpha\, mg\, 4\sin^2\alpha L^2$ (Från uppg. a)

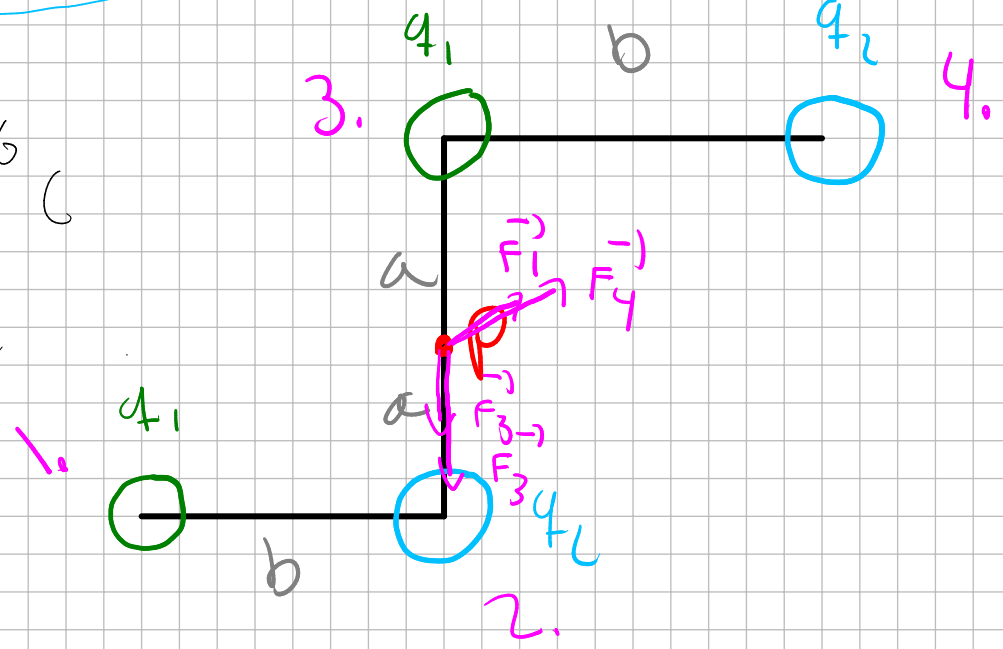
$$\tan\alpha \sin^2\alpha = \frac{kq^2}{4mgL^2} = \underline{34{,}5°}$$

Geogebra :)

(4)

$q_1 = 8{,}10 \cdot 10^{-6}\,C$

$q_2 = -10 \cdot 10^{-6}\,C$



$a = 0{,}3 \cdot 10^{-3}\,m$

$b = 0{,}4 \cdot 10^{-3}\,m$

Sier P har laddning Q

$$E = \frac{V}{d}$$

$$\sum_{j=1}^{4} \frac{F_j}{Q} = \frac{V}{d}$$

$$V = \sum_{j=0}^{4} \frac{k q_j}{r_j^2} d \quad , \; d = r \quad ; \text{ dette tilfellet}$$

$$V = k \sum_{j=1}^{4} \frac{q_j}{r_j}$$

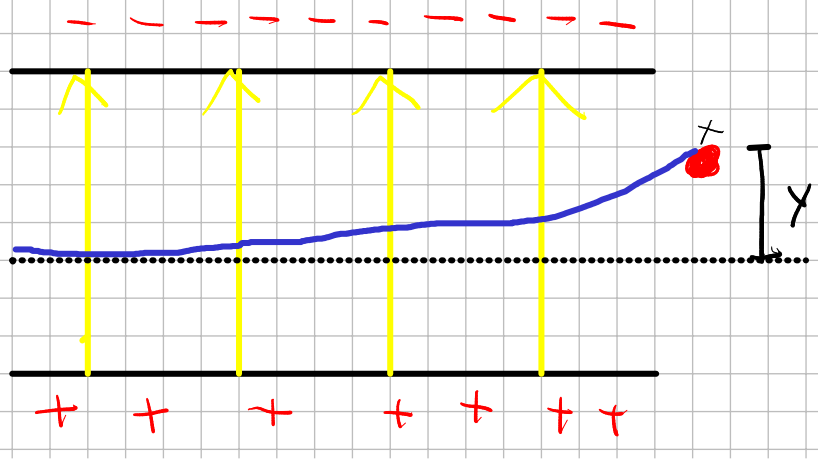
$$V = k \left(\frac{q_1}{\sqrt{a^2+b^2}} + \frac{q_2}{b} + \frac{q_1}{a} + \frac{q_2}{\sqrt{a^2+b^2}} \right)$$

$$V = 8{,}99 \cdot 10^{-9} \frac{Nm^2}{C^2} \left(\frac{5{,}10 \cdot 10^{-6}\,C}{\sqrt{(0{,}3 \cdot 10^{-3}\,m)^2 + (0{,}4 \cdot 10^{-3}\,m)^2}} + \frac{10 \cdot 10^{-6}\,C}{0{,}4 \cdot 10^{-3}\,m} + \right.$$

$$\left. \frac{5{,}10 \cdot 10^{-6}\,C}{0{,}3 \cdot 10^{-3}\,m} + \frac{10 \cdot 10^{-6}\,C}{\sqrt{(0{,}3 \cdot 10^{-3}\,m)^2 + (0{,}4 \cdot 10^{-3}\,m)^2}} \right)$$

$$\underline{\underline{V = -2{,}4 \cdot 10^{8}\,V}}$$

(5)



q

$d = 2{,}0 \cdot 10^{-2}\ m$ $\quad E = 8{,}0 \cdot 10^{4}\ \frac{N}{C}$

$m = 1{,}4 \cdot 10^{-8}\ kg$ $\quad v_0 = 20\ m/s$

$y = 0{,}13 \cdot 10^{-3}\ m$

$F_E \perp G \Rightarrow$ Ser bortiform G

$E = \frac{F_E}{q} \Rightarrow \quad q = \frac{F_E}{E}$

$\sum f_y = ma$

$f_E = ma$

x:

$d = v_{0x} \cdot t$

$t = \frac{d}{v_0}$

y:

$y = v_{0y} t + \frac{1}{2} a t^2$

$y = \frac{1}{2} a t^2$

$a = \frac{2y}{t^2}$

$a = \frac{2y \cdot v_0^2}{d^2}$

$$F_E = \frac{m \, 2y V_0^2}{d^2}$$

$$q = \frac{2 m y V_0^2}{d^2 E}$$

$$q = \frac{2 \cdot 1{,}4 \cdot 10^{-8}\ kg \cdot 0{,}3 \cdot 10^{-3}\ m \cdot (20\ m/s)^2}{(0{,}02\ m)^2 \cdot 8{,}0 \cdot 10^4\ \frac{N}{C}}$$

$$q = 1{,}1 \cdot 10^{-10}\ C$$

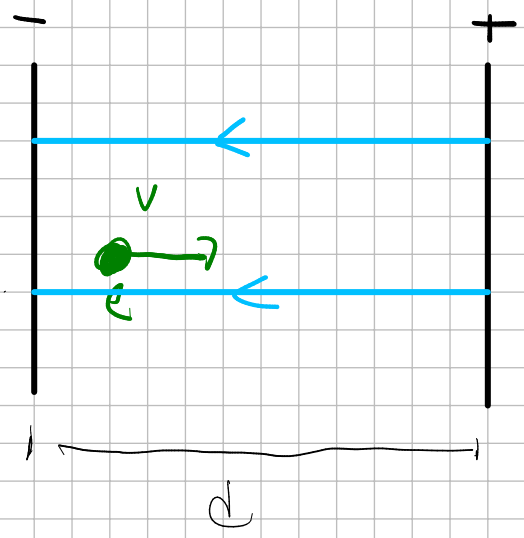
(6)

$$E = 100 \cdot 10^6\ \frac{V}{m}$$

$V_0 = 0$

$v = 3{,}0 \cdot 10^7\ m/s$

$F_E \perp\!\!\!\perp 6 \Rightarrow$ bryr oss ikke om 6



$$\sum F = ma$$

$$F_E = ma$$

$$Ee = ma \Rightarrow a = \frac{Ee}{m}$$

$$v^2 - v_0^2 = 2ad$$

$$d = \frac{v^2}{2a}$$

$$d = \frac{v^2 m}{2Ee} = \frac{(3{,}0 \cdot 10^7\ m/s)^2 \cdot 9{,}11 \cdot 10^{-31}\ kg}{2 \cdot 100 \cdot 10^6\ \frac{V}{m} \cdot 1{,}60 \cdot 10^{-19}\ C}$$

$$\underline{\underline{d = 2{,}6 \cdot 10^{-5}\ m}}$$