task_5u1zbroaz75w39jk_with_calculation

Student Group

First Name	Surname	Matrikel Nr.

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electrostatic, field lines, exam ee2 SS2024

Exercise E1 Electrostatics I
(written test, approx. 8 % of a 120-minute written test, SS2024)

2. What is the magnitude of the resulting force on the charge q_0? The values of the point charges are E_4. Which value needs E_4 to have to get a resulting force of $0 ~\rm N$ on q_0?

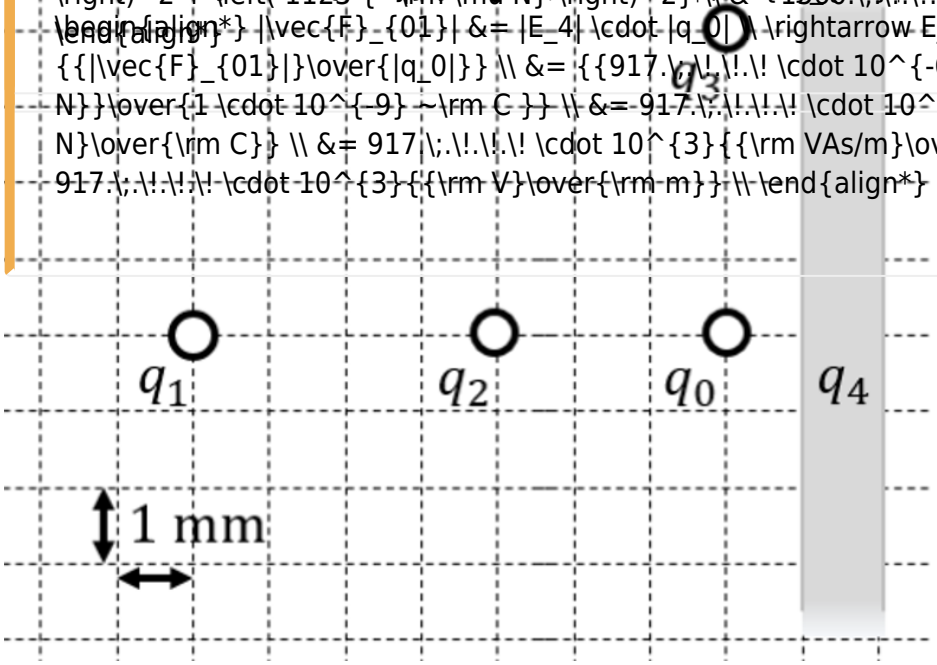
- $q_0=-1 ~\rm nC$
- $q_1=-5 ~\rm nC$
- $E_4 = 1560 ~\rm V/m$
- $r = 7 ~\rm mm$
- $\vec{F}_{01} = \left(\begin{array}{cccc} 917 {~\rm \mu N} \\ 0 \\ 0 \end{array} \right)$
- $\vec{F}_{02} = \left(\begin{array}{cccc} 1997 {~\rm \mu N} \\ 0 \\ 0 \end{array} \right)$
- $\vec{F}_{03} = \left(\begin{array}{cccc} 1123 {~\rm \mu N} \\ 0 \\ 0 \end{array} \right)$

In the beginning the area charge is $q_4 = 0 ~\rm nC$.

The permittivity is given as $\varepsilon_0 = 8.854 \cdot 10^{-12} ~\rm As/Vm$

Here, the relation between the force $\vec{F}_{01}$ from q_1 on q_0:

$$\begin{aligned} |\vec{F}_{01}| &= |E_4| \cdot |q_0| \quad \rightarrow E_4 = \frac{|\vec{F}_{01}|}{|q_0|} \\ &= \frac{917 \cdot 10^{-6} ~\rm N}{1 \cdot 10^{-9} ~\rm C} \\ &= 917 \cdot 10^{3} \frac{\rm N}{\rm C} \\ &= 917 \cdot 10^{3} \frac{\rm VAs/m}{\rm As} \\ &= 917 \cdot 10^{3} \frac{\rm V}{\rm m} \end{aligned}$$



1. Calculate the single forces $\vec{F}_{01}$, $\vec{F}_{02}$, $\vec{F}_{03}$, on the charge q_0!

Path

First, calculate the magnitude of the forces, like $\vec{F}_{01}$.
The force $\vec{F}_{01}$ is purely on the x-axis and therefore equal to $F_{01,x}$. $$\begin{aligned} \vec{F}_{01} = F_{01,x} &= \frac{1}{4\pi\varepsilon}\cdot \frac{q_1\cdot q_0}{r^2_{01}} \\ &= \frac{1}{4\pi\cdot 8.854 \cdot 10^{-12} ~\rm As/Vm}\cdot \frac{1 \cdot 10^{-9} ~\rm C \cdot 5 \cdot 10^{-9} ~\rm C}{(7 \cdot 10^{-3} ~\rm m)^2} \\ &=

$$917.\;.\!.\!.\!.\! \cdot 10^{-6} {\rm {{(As)^2 \cdot Vm}\over{As \cdot m^2}}} = 917.\;.\!.\!.\!.\! \cdot 10^{-6} {\rm {{VAs}\over{m}}} = 917.\;.\!.\!.\!.\! \cdot 10^{-6} {\rm {{Ws}\over{m}}} \\ &= 917.\;.\!.\!.\!.\! {\rm \mu N} \quad \text{(to the right)} \end{align*}$$

Similarly, we get for $\vec{F}_{02}$ and $\vec{F}_{03}$ $$\begin{align*} \vec{F}_{02} = F_{02,x} &= -1997.\;.\!.\!.\!.\! {\rm \mu N} \quad \text{(to the right)} \\ \vec{F}_{03} = F_{03,y} &= -1123.\;.\!.\!.\!.\! {\rm \mu N} \quad \text{(to the top)} \\ \end{align*}$$