

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 has to be the charge of the plates that create the electric field shown in the picture below? The value of the point charge is $q_0 = 1 \text{ nC}$. Which value needs E_4 to have to get a resulting force of 0 nN on q_0 ?

Path: $q_0 = -1 \text{ nC}$

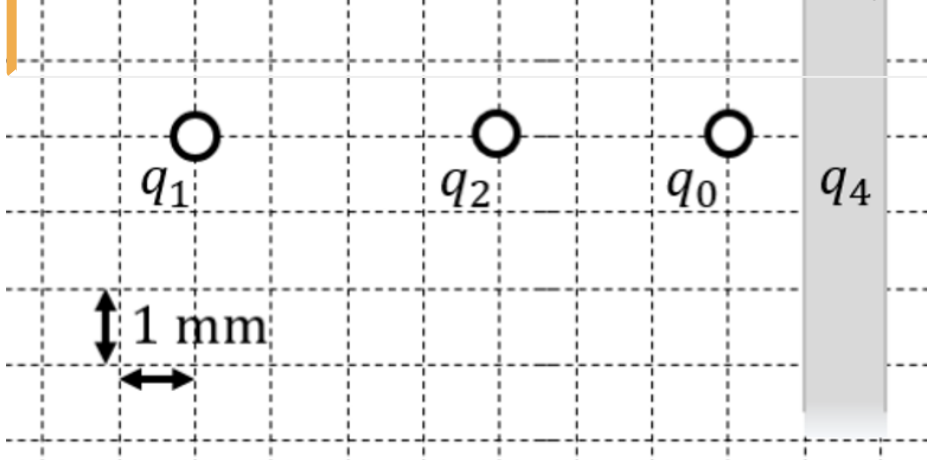
- $q_1 = -5 \text{ nC}$

Path: $E_4 = 907 \text{ (from 1 nN) / q_0}$

- $\vec{F}_{01} = \left(\begin{array}{c} 917 \\ 0 \\ 0 \end{array} \right) \cdot 10^{-6} \text{ N}$

In the x -direction the same force components, we can calculate the resulting magnitude of the force F_{01} by the position of the charges. The permittivity is $\epsilon_0 = 8.854 \cdot 10^{-12} \text{ As/Vm}$. In the x -direction $F_{01} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 \cdot q_0}{r_{01}^2}$. Here, the field has to compensate the force \vec{F}_{01} from q_1 on q_0 :

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



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 $F_{01,x}$.

$$\vec{F}_{01} = F_{01,x} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 \cdot q_0}{r_{01}^2} = \frac{1}{4\pi \cdot 8.854 \cdot 10^{-12} \text{ As/Vm}} \cdot \frac{1 \cdot 10^{-9} \text{ C} \cdot 5 \cdot 10^{-9} \text{ C}}{(7 \cdot 10^{-3} \text{ m})^2}$$

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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}} \quad \&= 917.\;.\!.\!.\! {\rm \mu N} \quad \text{(to the right)}
\end{align*}

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

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