

# task\_5u1zbroaz75w39jk\_with\_calculation

## Student Group

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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)

Two point charges  $q_1$  and  $q_2$  are placed on the x-axis at  $x = 0$  and  $x = 1$  mm, respectively. A third point charge  $q_0$  is placed at  $x = 2$  mm. A fourth point charge  $q_4$  is placed at  $x = 3$  mm. Which value needs  $E_4$  to have to get a resulting force of  $0$  N on  $q_0$ ?

Path:  $q_0 = -1$  nC

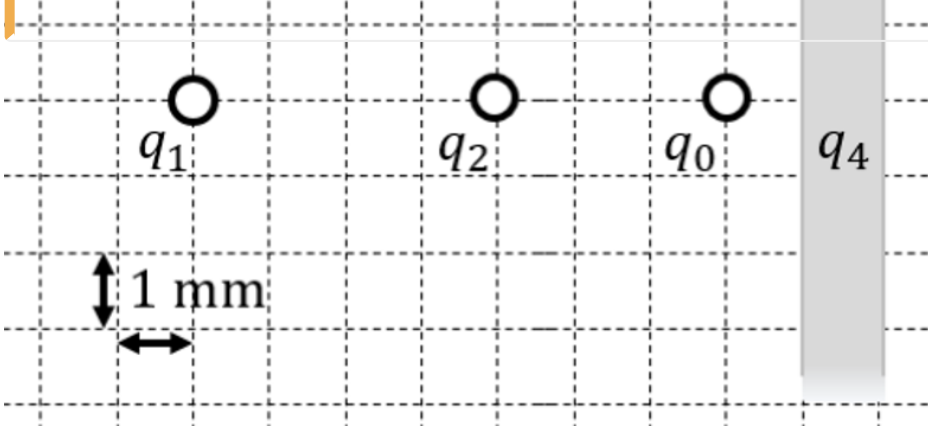
- $q_1 = -5$  nC

Path:  $E_4 = 907$  (from  $10^9$  N/C)

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

In the  $x$ -direction, the force components are  $F_{01} = 917 \cdot 10^{-6} \text{ N}$ . The force  $F_{02}$  is  $F_{02} = \frac{1}{4\pi\epsilon_0} \frac{q_0 q_2}{r_{02}^2} = \frac{1}{4\pi \cdot 8.85 \cdot 10^{-12} \text{ As/Vm}} \frac{(-1 \cdot 10^{-9} \text{ C}) \cdot (-5 \cdot 10^{-9} \text{ C})}{(1 \cdot 10^{-3} \text{ m})^2} = 1.123 \cdot 10^{-6} \text{ N}$ . Here, the field has to compensate the force  $\vec{F}_{01}$  from  $q_1$  on  $q_0$ :

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



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

Path

First, set up a coordinate system. Here, I choose  $x$  pointing to the right (positive values to the right) and  $y$  pointing upwards (positive values upwards).  
Then, calculate the magnitude of the forces, like  $\vec{F}_{01}$  (force on  $q_0$  from  $q_1$ ).  
The force  $\vec{F}_{01}$  is purely on the  $x$ -axis and therefore equal to

$$F_{01,x} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_0}{r_{01}^2} = \frac{1}{4\pi \cdot 8.854 \cdot 10^{-12}} \cdot \frac{1 \cdot 10^{-9} \cdot 5 \cdot 10^{-9}}{(7 \cdot 10^{-3})^2} = 917.4 \cdot 10^{-6} \frac{\text{As}^2 \cdot \text{Vm}}{\text{As} \cdot \text{m}^2} = 917.4 \cdot 10^{-6} \frac{\text{VAs}}{\text{m}} = 917.4 \cdot 10^{-6} \frac{\text{Ws}}{\text{m}}$$
 Since both  $q_0$  and  $q_1$  have the same sign for their charges, they are repelling each other. Therefore, The force  $\vec{F}_{01}$  points to the right (positive value).

Similarly, we get for  $\vec{F}_{02}$  and  $\vec{F}_{03}$ 

$$\vec{F}_{02} = F_{02,x} = -1997.4 \frac{\text{Ws}}{\text{m}}$$

$$\vec{F}_{03} = F_{03,y} = -1123.4 \frac{\text{Ws}}{\text{m}}$$
 Since  $q_0$  and  $q_2$  have the different sign for their charges, they are attract each other. Therefore, The force  $\vec{F}_{02}$  points to the left (negative value).  
 Since  $q_0$  and  $q_3$  have the different sign for their charges, they are attract each other. Therefore, The force  $\vec{F}_{03}$  points downwards (negative value).

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