

# task\_dtoqvpvrbdtozfk\_with\_calculation

## Student Group

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electrostatic, field lines, exam ee2 SS2022

**Exercise E1 Electrostatics I**

(written test, approx. 10 % of a 120-minute written test, SS2022)

2. What has been given to you? The charges are  $q_1 = 1 \text{ nC}$ ,  $q_2 = 2 \text{ nC}$ ,  $q_3 = 3 \text{ nC}$ ,  $q_4 = 4 \text{ nC}$ . The value of the point charge  $q_0$  is  $1 \text{ nC}$ . Which value needs  $E_4$  to have to get a resulting force of  $0 \text{ N}$  on  $q_0$ ?

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

- $q_1 = 2 \text{ nC}$

Path:  $E_4 = 2310.97 \text{ (nN/m)}$

- $\vec{F}_{01} = \left( \begin{array}{c} 19.97 \\ 0 \\ 0 \end{array} \right) \text{ (nN)}$

In the  $x$ -direction the force components are  $F_{01,x} = 19.97 \text{ (nN)}$ . The permittivity is  $\epsilon_0 = 8.854 \cdot 10^{-12} \text{ (As/Vm)}$ .

$$|\vec{F}_{01}| = \sqrt{\left( \sum_i F_{01,x} \right)^2 + \left( \sum_i F_{01,y} \right)^2} = \sqrt{19.97^2} = 19.97 \text{ (nN)}$$

$$|\vec{F}_{04}| = \sqrt{\left( \sum_i F_{04,x} \right)^2 + \left( \sum_i F_{04,y} \right)^2} = \sqrt{0^2 + 10.05^2} = 10.05 \text{ (nN)}$$

$$|\vec{F}_{04}| = q_0 \cdot E_4 \Rightarrow E_4 = \frac{|\vec{F}_{04}|}{q_0} = \frac{10.05 \text{ (nN)}}{1 \text{ (nC)}} = 10.05 \text{ (nV/m)}$$

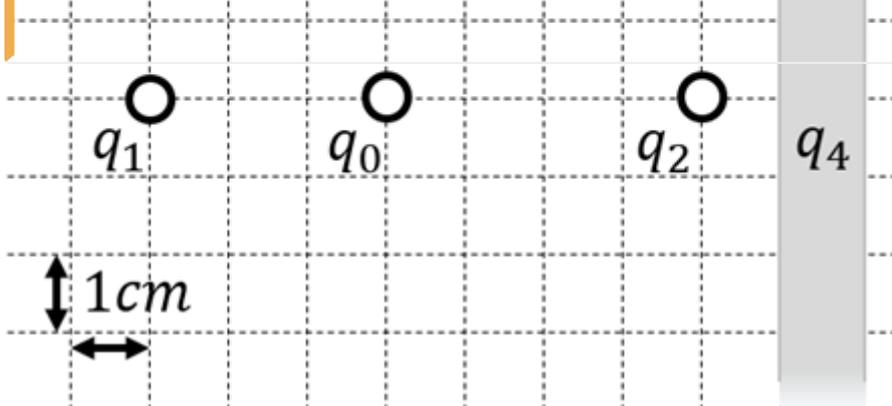
$$|\vec{F}_{01}| = q_0 \cdot E_1 \Rightarrow E_1 = \frac{|\vec{F}_{01}|}{q_0} = \frac{19.97 \text{ (nN)}}{1 \text{ (nC)}} = 19.97 \text{ (nV/m)}$$

$$\frac{|\vec{F}_{01}|}{q_0} = \frac{19.97 \text{ (nN)}}{1 \text{ (nC)}} = 19.97 \text{ (nV/m)}$$

$$19.97 \text{ (nV/m)} = 19.97 \text{ (nV/m)}$$

$$19.97 \text{ (nV/m)}$$

$$19.97 \text{ (nV/m)}$$



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

$$F_{01,x} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 \cdot q_0}{r_{01}^2} =$$

$$\frac{1}{4\pi \cdot 8.854 \cdot 10^{-12} \text{ (As/Vm)}} \cdot \frac{1 \text{ (nC)} \cdot 1 \text{ (nC)}}{(3 \cdot 10^{-2} \text{ (m)})^2} =$$

$$19.97 \text{ (nN)}$$

$$19.97 \text{ (nN)}$$

$$19.97 \text{ (nN)}$$

$\cdot 10^{-6} \left\{ \frac{V_A}{m} \right\} = 19.97... \cdot 10^{-6} \left\{ \frac{W}{m} \right\} \quad \&= 19.97... \left\{ \mu N \right\} \quad \text{(to the right)}$

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

$$\vec{F}_{02} = F_{02,x} \quad \&= -28.09... \left\{ \mu N \right\} \quad \text{(to the right)}$$

$$\vec{F}_{03} \quad \&= -22.47... \left\{ \mu N \right\} \quad \text{(to the top left)}$$

For  $\vec{F}_{03}$ , we have to calculate the  $x$ - and  $y$ -component.

This is possible, by using the angle  $\alpha$  between the line through  $q_0$  and  $q_3$  and the positive  $x$ -axis (pointing to the right).

So,  $\alpha$  has to be between  $90^\circ$  and  $180^\circ$ . It can be calculated by:

$$\alpha = \arctan\left(\frac{-4 \text{ cm}}{+2 \text{ cm}}\right) = \pi - 1.1071... = 180^\circ - 63.4...^\circ = 116.6...^\circ$$

Based on this, the  $x$ - and  $y$ -component is:

$$F_{03,x} \quad \&= |\vec{F}_{03}| \cdot \cos \alpha = 10.05... \left\{ \mu N \right\} \quad \text{(to the left)}$$

$$F_{03,y} \quad \&= |\vec{F}_{03}| \cdot \sin \alpha = 20.10... \left\{ \mu N \right\} \quad \text{(to the top)}$$

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