

# task\_dtoqvpvrbdtozfk\_with\_calculation

## Student Group

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## Table of Contents

Exercise E1 Electrostatics I (written test, approx. 10 % of a 120-minute written test, SS2022)  
..... 2

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  $q_1 = 1 \text{ nC}$ ,  $q_2 = 2 \text{ nC}$ ,  $q_0 = 1 \text{ nC}$ ,  $q_4 = 1 \text{ nC}$ . 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:  $E_4 = 2310.97 \text{ (V/m)}$

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

In the  $x$ -direction, the force components are  $F_{01,x} = 19.97 \text{ (}\mu\text{N)}$ . The force components in the  $y$ -direction are  $F_{01,y} = 0 \text{ (}\mu\text{N)}$ . The force components in the  $z$ -direction are  $F_{01,z} = 0 \text{ (}\mu\text{N)}$ .

$$|\vec{F}_{01}| = \sqrt{F_{01,x}^2 + F_{01,y}^2 + F_{01,z}^2} = \sqrt{19.97^2 + 0^2 + 0^2} = 19.97 \text{ (}\mu\text{N)}$$

$$|\vec{F}_{02}| = \sqrt{F_{02,x}^2 + F_{02,y}^2 + F_{02,z}^2} = \sqrt{10.05^2 + 0^2 + 0^2} = 10.05 \text{ (}\mu\text{N)}$$

$$|\vec{F}_{03}| = \sqrt{F_{03,x}^2 + F_{03,y}^2 + F_{03,z}^2} = \sqrt{10.05^2 + 0^2 + 0^2} = 10.05 \text{ (}\mu\text{N)}$$

$$|\vec{F}_{04}| = \sqrt{F_{04,x}^2 + F_{04,y}^2 + F_{04,z}^2} = \sqrt{10.05^2 + 0^2 + 0^2} = 10.05 \text{ (}\mu\text{N)}$$

$$|\vec{F}_{01}| = 19.97 \text{ (}\mu\text{N)}$$

$$|\vec{F}_{02}| = 10.05 \text{ (}\mu\text{N)}$$

$$|\vec{F}_{03}| = 10.05 \text{ (}\mu\text{N)}$$

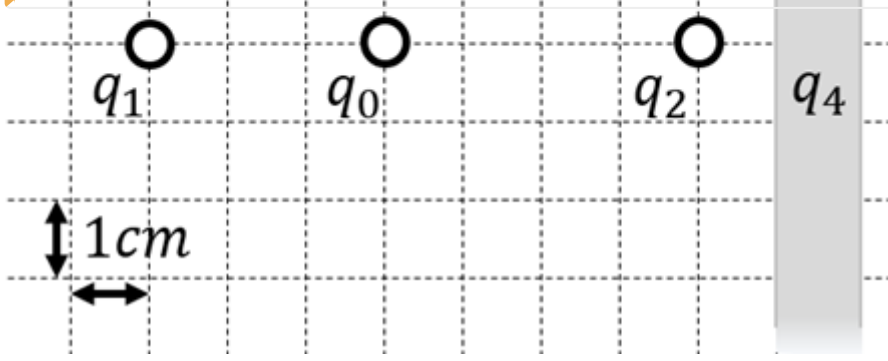
$$|\vec{F}_{04}| = 10.05 \text{ (}\mu\text{N)}$$

$$|\vec{F}_{01}| = 19.97 \text{ (}\mu\text{N)}$$

$$|\vec{F}_{02}| = 10.05 \text{ (}\mu\text{N)}$$

$$|\vec{F}_{03}| = 10.05 \text{ (}\mu\text{N)}$$

$$|\vec{F}_{04}| = 10.05 \text{ (}\mu\text{N)}$$



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  $F_{01,x}$ .

$$\vec{F}_{01} = F_{01,x} \hat{x}$$

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

$$F_{01,x} = \frac{1}{4\pi \cdot 8.854 \cdot 10^{-12} \text{ (As/Vm)}} \cdot \frac{1 \cdot 1 \cdot 10^{-9} \text{ (nC)}}{(3 \cdot 10^{-2} \text{ (m)})^2}$$

$$F_{01,x} = 19.97 \cdot 10^{-6} \text{ (}\mu\text{N)}$$

$$F_{01,x} = 19.97 \cdot 10^{-6} \text{ (}\mu\text{N)}$$

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

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

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

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

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:

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

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

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