

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 $q_1 = -1 \text{ nC}$, $q_2 = 2 \text{ nC}$, $q_0 = 1 \text{ nC}$, $q_4 = 1 \text{ nC}$. The value of the point charge q_0 is 1 nC . Which value needs E_4 to have to get a resulting force of 0 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 $F_{01,x} = 19.97 \text{ nN}$. We can calculate the resulting magnitude of the force F_{01} by using the Pythagorean theorem: $F_{01} = \sqrt{F_{01,x}^2 + F_{01,y}^2 + F_{01,z}^2} = \sqrt{19.97^2} = 19.97 \text{ nN}$.

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

Here, this F_{01} is the force from q_1 on q_0 . The force from q_2 on q_0 is $F_{02} = 10.05 \text{ nN}$.

The force from q_4 on q_0 is $F_{04} = 10.05 \text{ nN}$. The force from q_0 on q_0 is $F_{00} = 0 \text{ nN}$.

$$|\vec{F}_{01}| = |E_4| \cdot |q_0| \implies E_4 = \frac{|\vec{F}_{01}|}{|q_0|} = \frac{19.97 \text{ nN}}{1 \text{ nC}} = 19.97 \text{ nV/m}$$

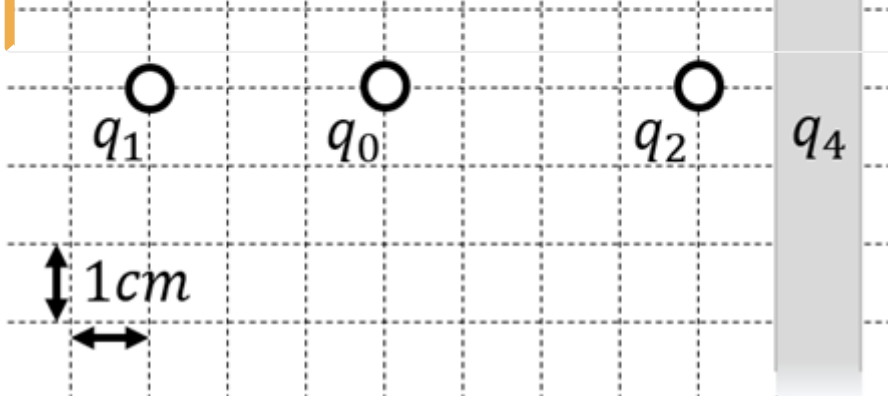
$$E_4 = \frac{19.97 \text{ nN}}{1 \text{ nC}} = 19.97 \text{ nV/m} = 19.97 \cdot 10^{-9} \text{ V/m} = 19.97 \cdot 10^{-3} \text{ V/m} = 19.97 \text{ mV/m}$$

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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 $F_{01,x}$.

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

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

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

$$19.97 \cdot 10^{-6} \text{ N} = \frac{(1 \text{ As}^2 \cdot \text{Vm})}{\text{As} \cdot \text{m}^2} = 19.97 \cdot 10^{-6} \text{ N}$$

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

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

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

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

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

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

So, α has to be between 90° and 180° . 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:

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

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

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