

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)

8. Which two charges are placed on the horizontal axis in the picture below? The values of the point charges are $q_1 = -1 \text{ nC}$, $q_2 = -5 \text{ nC}$, $q_0 = 1 \text{ nC}$, $q_4 = 1 \text{ nC}$. Which value needs E_4 to have to get a resulting force of 0 N on q_0 ?

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

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

Path: $E_4 = 917 \text{ V/m}$

- $\vec{F}_{01} = \left(\begin{array}{c} 917 \\ 0 \end{array} \right) \text{ nN}$

In the beginning, the same calculation as we can do. We can calculate the magnitude of the force F_{01} by using the formula $F = k \cdot \frac{q_1 \cdot q_0}{r^2}$ with $k = 8.99 \cdot 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$.

$$F_{01} = k \cdot \frac{q_1 \cdot q_0}{r^2} = 8.99 \cdot 10^9 \cdot \frac{(-1 \cdot 10^{-9}) \cdot (-5 \cdot 10^{-9})}{(0.001)^2} = 4.495 \cdot 10^{-5} \text{ N}$$

In the same way, we can calculate the force F_{02} and F_{03} .

$$F_{02} = k \cdot \frac{q_2 \cdot q_0}{r^2} = 8.99 \cdot 10^9 \cdot \frac{(-5 \cdot 10^{-9}) \cdot (1 \cdot 10^{-9})}{(0.002)^2} = -1.123 \cdot 10^{-4} \text{ N}$$

Here, the force F_{02} is negative, which means it points to the right.

$$\vec{F}_{01} = F_{01} \cdot \vec{e}_x = 4.495 \cdot 10^{-5} \text{ N} \cdot \vec{e}_x$$

$$\vec{F}_{02} = F_{02} \cdot \vec{e}_x = -1.123 \cdot 10^{-4} \text{ N} \cdot \vec{e}_x$$

$$\vec{F}_{03} = F_{03} \cdot \vec{e}_x = 1.123 \cdot 10^{-4} \text{ N} \cdot \vec{e}_x$$

$$\vec{F}_{04} = F_{04} \cdot \vec{e}_x = 1.123 \cdot 10^{-4} \text{ N} \cdot \vec{e}_x$$

$$\vec{F}_{01} + \vec{F}_{02} + \vec{F}_{03} + \vec{F}_{04} = 0 \text{ N}$$

$$4.495 \cdot 10^{-5} \text{ N} - 1.123 \cdot 10^{-4} \text{ N} + 1.123 \cdot 10^{-4} \text{ N} + 1.123 \cdot 10^{-4} \text{ N} = 0 \text{ N}$$

$$4.495 \cdot 10^{-5} \text{ N} + 1.123 \cdot 10^{-4} \text{ N} = 0 \text{ N}$$

$$1.572 \cdot 10^{-4} \text{ N} = 0 \text{ N}$$

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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 $F_{01,x}$.

$$\vec{F}_{01} = F_{01,x} \cdot \vec{e}_x$$

$$F_{01,x} = k \cdot \frac{q_1 \cdot q_0}{r^2} = 8.99 \cdot 10^9 \cdot \frac{(-1 \cdot 10^{-9}) \cdot (-5 \cdot 10^{-9})}{(0.001)^2} = 4.495 \cdot 10^{-5} \text{ N}$$

$$\vec{F}_{01} = 4.495 \cdot 10^{-5} \text{ N} \cdot \vec{e}_x$$

$$\vec{F}_{02} = k \cdot \frac{q_2 \cdot q_0}{r^2} = 8.99 \cdot 10^9 \cdot \frac{(-5 \cdot 10^{-9}) \cdot (1 \cdot 10^{-9})}{(0.002)^2} = -1.123 \cdot 10^{-4} \text{ N}$$

$$\vec{F}_{02} = -1.123 \cdot 10^{-4} \text{ N} \cdot \vec{e}_x$$

$$\vec{F}_{03} = k \cdot \frac{q_3 \cdot q_0}{r^2} = 8.99 \cdot 10^9 \cdot \frac{(1 \cdot 10^{-9}) \cdot (1 \cdot 10^{-9})}{(0.002)^2} = 1.123 \cdot 10^{-4} \text{ N}$$

$$\vec{F}_{03} = 1.123 \cdot 10^{-4} \text{ N} \cdot \vec{e}_x$$

$$917. \cdot 10^{-6} \frac{\text{As}^2 \cdot \text{Vm}}{\text{As} \cdot \text{m}^2} = 917. \cdot 10^{-6} \frac{\text{VAs}}{\text{m}} = 917. \cdot 10^{-6} \frac{\text{Ws}}{\text{m}} \quad \&= 917. \cdot 10^{-6} \mu\text{N} \quad \text{(to the right)}$$

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

$$\vec{F}_{02} = F_{02,x} \quad \&= -1997. \cdot 10^{-6} \mu\text{N} \quad \text{(to the right)}$$

$$\vec{F}_{03} = F_{03,y} \quad \&= -1123. \cdot 10^{-6} \mu\text{N} \quad \text{(to the top)}$$

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Last update: 2024/07/15 15:18

