

task_5u1zbroaz75w39jk_with_calculation

Student Group

First Name	Surname	Matrikel Nr.

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Exercise E1 Electrostatics I**(written test, approx. 8 % of a 120-minute written test, SS2024)**

5. Which two charges are placed on the horizontal axis in the picture below. The values of the point charges are $q_1 = -1 \text{ nC}$, $q_2 = -5 \text{ nC}$, $q_0 = 1 \text{ nC}$, and $q_4 = 1 \text{ nC}$. 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: $E_4 = 500 \text{ V/m}$

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

In the beginning, the same calculation is done, we can calculate the resulting magnitude of the force F_{01} by using the formula $F = k \cdot \frac{q_1 \cdot q_2}{r^2}$ with $k = 8.99 \cdot 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$.

The force F_{01} is purely on the x -axis and therefore equal to $F_{01} = 917 \cdot 10^{-6} \text{ N}$.

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

In the same way, the force F_{02} is calculated to be $F_{02} = 1123 \cdot 10^{-6} \text{ N}$.

Here, the force has components in the force $\vec{F}_{02} = \left(\begin{array}{c} -1560 \\ 1123 \end{array} \right) \cdot 10^{-6} \text{ N}$.

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

$$\vec{F}_{02} = \left(\begin{array}{c} -1560 \\ 1123 \end{array} \right) \cdot 10^{-6} \text{ N}$$

$$\vec{F}_{03} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{04} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{05} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{06} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{07} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{08} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{09} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{10} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{11} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{12} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{13} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{14} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{15} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{16} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{17} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{18} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{19} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{20} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{21} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{22} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{23} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{24} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{25} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{26} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{27} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{28} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{29} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{30} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{31} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{32} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{33} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{34} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{35} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{36} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{37} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{38} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{39} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{40} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{41} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{42} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{43} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

$$\vec{F}_{44} = \left(\begin{array}{c} 0 \\ 0 \end{array} \right) \text{ N}$$

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

$$\begin{aligned} F_{01,x} &= \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 \cdot q_0}{r_{01}^2} \\ &= \frac{1}{4\pi \cdot 8.854 \cdot 10^{-12} \cdot \text{As/Vm}} \cdot \frac{1 \cdot 10^{-9} \cdot 5 \cdot 10^{-9}}{(7 \cdot 10^{-3})^2} \\ &= 917. \cdot 10^{-6} \cdot \frac{(As)^2 \cdot Vm}{As \cdot m^2} = 917. \cdot 10^{-6} \cdot \frac{VAs}{m} = 917. \cdot 10^{-6} \cdot \mu N \end{aligned}$$
 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 $\vec{F}_{03}$

$$\begin{aligned} \vec{F}_{02} &= F_{02,x} = -1997. \cdot 10^{-6} \cdot \mu N \\ \vec{F}_{03} &= F_{03,y} = -1123. \cdot 10^{-6} \cdot \mu N \end{aligned}$$
 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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