

task_5u1zbroaz75w39jk_with_calculation

Student Group

First Name	Surname	Matrikel Nr.

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Exercise E1 Electrostatics I**(written test, approx. 10 % of a 120-minute written test, SS2024)**

5. Which two charges of the picture are positive? The charges of the point charges are $q_1 = 1 \text{ nC}$, $q_2 = 2 \text{ nC}$, $q_3 = 3 \text{ nC}$, $q_4 = 4 \text{ nC}$. Which value needs E_4 to have to get a resulting force of 0 N on q_0 ?

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

- $q_1 = -2 \text{ nC}$

Path: $E_4 = 2310.97 \text{ V/m}$

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

In the beginning, the same calculation as we can do. We can calculate the resulting magnitude of the force F_{01} by using the formula $F = k \cdot \frac{q_1 \cdot q_0}{r^2}$. Here, $k = 8.99 \cdot 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$, $q_1 = 1 \text{ nC}$, $q_0 = -1 \text{ nC}$, and $r = 1 \text{ cm} = 0.01 \text{ m}$. So, $F_{01} = 8.99 \cdot 10^9 \cdot \frac{1 \cdot (-1)}{(0.01)^2} = -8.99 \cdot 10^9 \text{ N}$. The negative sign indicates that the force is attractive.

Here, this formula is used to calculate the force F_{01} on q_0 due to q_1 .

$\vec{F}_{01} = \left(\begin{array}{c} -8.99 \cdot 10^9 \\ 0 \end{array} \right) \text{ N}$

$\vec{F}_{02} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{03} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{04} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{05} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{06} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{07} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{08} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{09} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{010} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{011} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{012} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{013} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{014} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{015} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{016} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{017} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{018} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{019} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{020} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{021} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{022} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{023} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{024} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{025} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{026} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{027} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{028} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{029} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{030} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{031} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{032} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{033} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{034} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{035} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{036} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{037} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{038} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{039} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{040} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

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

$F_{01,x}$.

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

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

$\vec{F}_{02} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{03} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\vec{F}_{04} = \left(\begin{array}{c} 0 \\ 19.97 \end{array} \right) \text{ nN}$

$\cdot 10^{-6} \text{ \rm \{VAs\}\over\{m\}} = 19.97... \cdot 10^{-6} \text{ \rm \{Ws\}\over\{m\}} \quad \&= 19.97... \text{ \rm \mu N} \quad \text{\text{(to the right)}} \quad \end{align*}$

Similarly, we get for $\vec{F}_{02}$ and $\vec{F}_{03}$ $\begin{align*} \vec{F}_{02} = F_{02,x} \quad \&= -28.09... \text{ \rm \mu N} \quad \text{\text{(to the right)}} \quad \\ \vec{F}_{03} \quad \&= -22.47... \text{ \rm \mu N} \quad \text{\text{(to the top left)}} \quad \end{align*}$

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:

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

Based on this, the x - and y -component is: $\begin{align*} F_{03,x} \quad \&= |\vec{F}_{03}| \cdot \cos \alpha = 10.05... \text{ \rm \mu N} \quad \text{\text{(to the left)}} \quad \\ F_{03,y} \quad \&= |\vec{F}_{03}| \cdot \sin \alpha = 20.10... \text{ \rm \mu N} \quad \text{\text{(to the top)}} \quad \end{align*}$

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