

task_1.2.5_with_calc

Student Group

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Task 1.2.5 Forces on Charges (exam task, ca 8 % of a 60 minute exam, WS2020)

Given is an arrangement of electric charges located in a vacuum (see picture on the right).

The charges have the following values:

$Q_1 = 7 \text{ } \mu\text{C}$ (point charge)

$Q_2 = 5 \text{ } \mu\text{C}$ (point charge)

$Q_3 = 0 \text{ C}$ (infinitely extended surface charge)

$\epsilon_0 = 8.854 \cdot 10^{-12} \text{ F/m}$, $\epsilon_r = 1$

1. calculate the magnitude of the force of Q_2 on Q_1 , without the force effect of Q_3 .

Tips for the solution

- Which equation is to be used for the force effect of charges?
- How can the distance between the two charges be determined?

Solution

$$\begin{aligned} F_C &= \frac{1}{4\pi \epsilon_0} \cdot \frac{Q_1 \cdot Q_2}{r^2} \quad \& \quad | \quad \text{with } r = \sqrt{\Delta x^2 + \Delta y^2} \quad \& \quad F_C = \frac{1}{4\pi \epsilon_0} \cdot \frac{Q_1 \cdot Q_2}{\Delta x^2 + \Delta y^2} \quad \& \quad \\ &| \quad \text{Insert numerical values, read off distances: } \Delta x = 5 \text{ dm}, \Delta y = 3 \text{ dm} \quad \& \quad F_C = \frac{1}{4\pi \cdot 8.854 \cdot 10^{-12} \text{ F/m}} \cdot \frac{7 \cdot 5 \cdot 10^{-6} \text{ C} \cdot 5 \cdot 10^{-6} \text{ C}}{(0.5 \text{ m})^2 + (0.2 \text{ m})^2} \end{aligned}$$

Result

$$\begin{align*} |\vec{F}_C| &= 1.084 \text{ ~}\mathrm{N} \rightarrow 1.1 \text{ ~}\mathrm{N} \end{align*}$$

2. is this force attractive or repulsive?

Tips for the solution

- What force effect do equally or oppositely charged bodies exhibit on each other?

Solution

The force is repulsive because both charges have the same sign.

Now let $Q_2=0$ and the surface charge Q_3 be designed in such a way that a homogeneous electric field with $E_3=100 \text{ ~}\mathrm{kV/m}$ results.
What force (magnitude) now results on Q_1 ?

Tips for the solution

- Which equation is to be applied for the force action in the homogeneous field?

Solution

$$\begin{align*} F_C &= E \cdot Q_1 \quad \& | \text{Insert numerical values} \quad F_C &= 100 \\ &\quad \cdot 10^3 \text{ ~}\mathrm{V/m} \cdot 7 \cdot 10^{-6} \text{ ~}\mathrm{C} \end{align*}$$

Result

$$\begin{align*} |\vec{F}_C| &= 0.7 \text{ ~}\mathrm{N} \end{align*}$$

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