task_1.1.3_with_calc

Student Group

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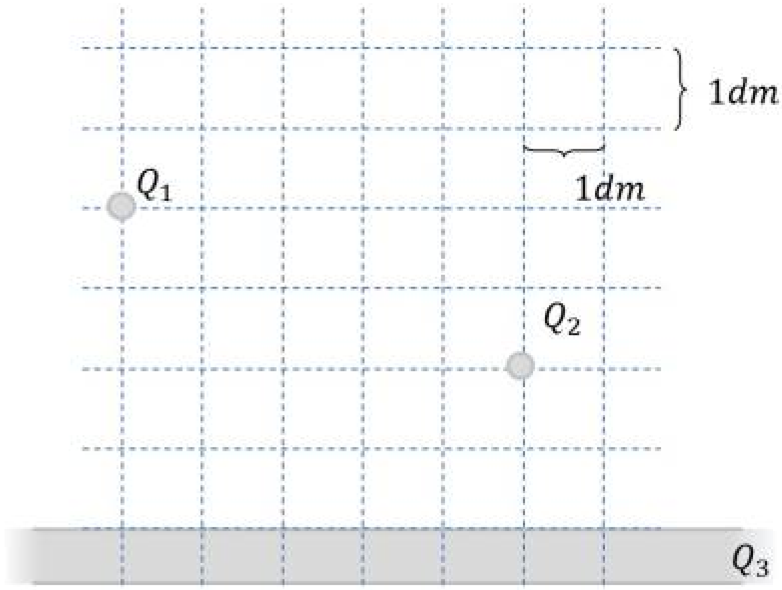
Task 1.1.3 Forces on Charges (exam task, ca 8% of a 60 minute exam, WS2020)



Given is an arrangement of electric charges located in a vacuum (see picture on the right).
The charges have the following values:
$Q_1=7 µC$ (point charge)
$Q_2=5 µC$ (point charge)
$Q_3=0 C$ (infinitely extended surface charge)

$\varepsilon_0=8.854\cdot 10^{-12} F/m$, $\varepsilon_r=1$

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{align*} F_C &= {{{1} \over {4\pi\cdot\varepsilon}} \cdot {{Q_1 \cdot Q_2} \over {r^2}}} \quad && | \text{with } r=\sqrt{\Delta x^2 + \Delta y^2} \\ F_C &= {{{1} \over {4\pi\cdot\varepsilon}} \cdot {{Q_1 \cdot Q_2} \over {\Delta x^2 + \Delta y^2}}} \quad && | \text{Insert numerical values, read off distances: } \Delta x = 5dm, \Delta y = 3dm \\ F_C &= {{{1} \over {4\pi\cdot 8,854\cdot 10^{-12} F/m}} \cdot {{7 \cdot 10^{-6} C \cdot 5 \cdot 10^{-6} C} \over { (0.5m)^2 + (0.2m)^2}}} \end{align*}

Result

\begin{align*} |\vec{F}_C| = 1.084 N \rightarrow 1.1 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 $E_3=100 kV/m$ 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

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

Result

$$\begin{align*} |\vec{F}_C| = 0.7 N \end{align*}$$

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