task_1.2.1_with_calc

Student Group

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Table of Contents

Task 1.2.1 Multiple Forces on a Charge I (exam task, ca 8% of a 60-minute exam, WS2020)

Given is the arrangement of electric charges in the picture on the right.
The following force effects result:
$F_{01}=-5 ~\rm{N}$
$F_{02}=-6 ~\rm{N}$
$F_{03}=+3 ~\rm{N}$

Calculate the magnitude of the resulting force.

Tips for the Solution

- How have the forces be prepared, to add them correctly?

Solution

\begin{align*} F_0 &= |\vec{F_0}| \quad \quad \text{ with } \vec{F_0} = \left(\begin{matrix}{F_{x,0}}\\ {F_{y,0}} \end{matrix} \right) = \left(\begin{matrix} \sum\limits_{n} F_{x,0n} \\ \sum\limits_{n} F_{y,0n} \end{matrix} \right) \\ F_0 &= \sqrt{ \left(\sum\limits_{n} F_{x,0n} \right)^2 + \left(\sum\limits_{n} F_{y,0n} \right)^2 } \\ \end{align*}

The forces have to be resolved into coordinates. Here, it is recommended to use an orthogonal coordinate system (x and y).
The coordinate system shall be in such a way, that the origin lies in Q_0, the x-axis is directed towards Q_3 and the y-axis is orthogonal to it.

For the resolution of the coordinates, it is necessary to get the angles α_{0n} of the forces with respect to the x-axis.
In the chosen coordinate system this leads to: $\alpha_{0n} = \arctan(\frac{\Delta y}{\Delta x})$
$\alpha_{01} = \arctan(\frac{3}{1})= 1.249 = 71.6°$
$\alpha_{02} = \arctan(\frac{4}{3})= 0.927 = 53.1°$
$\alpha_{03} = \arctan(\frac{0}{3})= 0= 0°$

Consequently, the resolved forces are:

$$\begin{align*} F_{x,0} &= F_{x,01} + F_{x,02} + F_{x,03} && | \quad \text{with } F_{x,0n} = F_{0n} \cdot \cos(\alpha_{0n}) \\ F_{x,0} &= (-5~\rm{N}) \cdot \cos(71.6°) + (-6~\rm{N}) \cdot \cos(53.1°) + (+3~\rm{N}) \cdot \cos(0°) \\ F_{x,0} &= -9.54 ~\rm{N} \\ \\ F_{y,0} &= F_{y,01} + F_{y,02} + F_{y,03} && | \quad \text{with } F_{y,0n} = F_{0n} \cdot \sin(\alpha_{0n}) \\ F_{y,0} &= (-5~\rm{N}) \cdot \sin(71.6°) + (-6~\rm{N}) \cdot \sin(53.1°) + (+3~\rm{N}) \cdot \sin(0°) \\ F_{y,0} &= -2.18 ~\rm{N} \\ \\ \end{align*}$$

Result

$$\begin{align*} F_0 &= \sqrt{ (-9.54 ~\rm{N})^2 + (-2.18 ~\rm{N})^2} = 9.79 ~\rm{N} \rightarrow 9.8 ~\rm{N} \\ \end{align*}$$